NO
PAPER
RIGHTS

REIMPRESSION
INTERDITE

PHYSICAL AND CHEMICAL CHARACTERISTICS OF NATURAL GAS PROCESSING PLANT WASTE SLUDGES AND SOLIDS

CANADIAN PETROLEUM ASSOCIATION

93-00021/

PHYSICAL AND CHEMICAL CHARACTERISTICS OF NATURAL GAS PROCESSING PLANT WASTE SLUDGES AND SOLIDS

Prepared for:

Canadian Petroleum Association
and
Environment Canada

Prepared by:

David Bromley Engineering (1983) Ltd.

FEBRUARY, 1991

Funding for this research was provided by the Canadian Petroleum Association's Environmental Research Advisory Council (ERAC) and Environment Canada resources obtained from the Federal Panel for Energy Research and Development (PERD).

The Canadian Petroleum Association has made every effort to assure the accuracy and reliability of the information and data contained in this document. However, the Canadian Petroleum Association makes no representation, warranty or guarantee as to the legality, reliability or acceptability of the information contained herein and hereby disclaims any liability for any loss or damage arising from the issue of this document or for violation of any federal, provincial or municipal laws, by-laws or regulations. Use of trade names by the authors does not represent endorsement by the Canadian Petroleum Association.

ACKNOWLEDGEMENTS

David Bromley Engineering (1983) Ltd. (DBEL) wishes to acknowledge the assistance of the Steering Committee throughout this project. Members of the Steering Committee were as follows:

- Mr. R. K. Johnson, Chairman, Shell Canada Limited
- Mr. R. P. Scroggins, Environment Canada
- Mr. A. Fernandes, Alberta Environment
- Mr. B. Byers, Gulf Canada Resources Ltd.
- Mr. A. Cummins, Alberta Environment
- Mr. R. Creasy, Energy Resources Conservation Board
- Mr. S. Skarstol, Energy Resources Conservation Board
- Ms. S. Halla, Energy Resources Conservation Board
- Mr. M. J. Burley, Esso Resources Canada Ltd.
- Mr. M. Bradshaw, Petro-Canada Inc.

DBEL also acknowledges the assistance provided by the following companies in providing the sludge samples used in the project:

- Alberta Natural Gas Co. Ltd.

- Amoco Canada Petroleum Company Limited
- BP Resources Canada Limited
- Esso Resources Canada Ltd.
- Gulf Canada Resources Ltd.
- Husky Oil Operations Ltd.
- Norcen Energy Resources Limited
- Petro-Canada Inc.
- Shell Canada Limited

In addition, DBEL acknowledges the services provided by Chemex Labs Alberta Inc., who carried out the laboratory analysis of the sludge samples.

Funding for this project was provided by the Environmental Research Advisory Council of the Canadian Petroleum Association and the Federal Panel for Energy Research and Development.

EXECUTIVE SUMMARY

This report presents the findings of a study undertaken to develop a data base of physical and chemical characteristics for 16 different waste sludges and solids produced by the natural gas processing industry. The study represents Phase I of a three phase project designed to assess treatment technology options for these waste materials. The results of this study will be used in phases II and III to specifically evaluate a number of treatment technology options.

The study involved assembling the data base with information obtained from both a review of existing data, and a comprehensive field sampling and laboratory analytical program. The field sampling and laboratory analytical program generally involved obtaining three samples of each sludge type from different gas plants, and having these sludges analyzed for as many as 40 different physical and chemical parameters. A summary of the sampling and analytical program is presented in Table 2.

An assessment of the quality of the data base was also prepared using the results obtained from the laboratory quality control program implemented for the project. In addition, a preliminary evaluation of the physical and chemical characteristics of the sludges and solids as they relate to the definition of a hazardous waste as defined in the Alberta Hazardous Waste Regulation, was carried out. While not originally a part of the project scope of work, this evaluation was undertaken because a number of the parameters analyzed in the laboratory analytical program can be used to evaluate the classification of the sludges relative to the Hazardous Waste Regulation.

The study concludes that in general, the quality of the data base is acceptable for the evaluation of treatment technology options. However, limited data was obtained on oil and water contents for amine, glycol, inlet separator and sulfinol sludges as a result of analytical problems encountered with the analysis of oil and grease and water content on some of the samples. It was also concluded that the laboratory analytical procedures used to determine

TABLE 2 - LABORATORY ANALYTICAL PROGRAM

SLUDGE TYPE	# OF SAMPLES			PARAMETERS ANALYZED																						
	TOTAL	SOUR PLANTS	SWEET PLANTS	BOD5	TOC	TP	TKN	NITRATE	SULFIDE	SULPHATE	TSS	VSS	% SOLIDS	% WATER	OIL & GREASE	BTU CONTENT	TOTAL S	S.G.	pH	ROUTINE CATIONS/ANIONS (1)	PARTICLE SIZE DISTRIBUTION	ELECTRICAL CONDUCTIVITY	FLASHPOINT/FLAMMABILITY (2)	LEACHATE (3)	FREE LIQUIDS	Cr
1. FLARE KNOCK-OUT	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
2. COOLING TOWER	3	3	1	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X		X	X	X
3. PROCESS FLOOR DRAIN	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
4. DEA AMINE	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
5. MEA AMINE	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
6. DIGESTOR	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
7. FILTER BACKWASH POND	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
8. FLARE PIT	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
9. GLYCOL SYSTEM	3	3	1	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
10. INLET SEPARATOR	3	3	1	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
11. LIME	3	3	0										X	X	X	X	X	X	X	X	X	X		X	X	
12. NEUT. SULPHUR POND	3	3	0										X	X	X	X	X	X	X	X	X	X		X	X	
13. PROCESS POND	8	8	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
14. SULFINOL	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
15. UN-NEUT. SULPHUR POND	3	3	0										X	X	X	X	X	X	X	X	X	X		X	X	
16. WATER TREATMENT	3	3	0										X	X	X	X	X	X	X	X	X	X		X	X	

(C:\LOTUS\221\SUP-TAB02.WK1)

(1) Routine Cations/Anions include Ca2+, Mg2+, Na+, K+, Cl- and HCO3-.

(2) Leachate tests to be carried out on sludges not classified under TDGR classes 3, 4 and 8 based on the flashpoint, flammability and pH analyses. Parameters to be analyzed include As, Ba, B, Cd, Cr, Pb, Hg, Se, CN and NO2/NO3.

(3) Flashpoint test was carried out on liquids. Flammability test was carried out on solids.

the concentrations of selected parameters in the sludges and solids were generally acceptable. However, suitable procedures for the measurement of oil and water contents in some amine, glycol, inlet separator and sulfinol sludge samples were not found. Finally, it was concluded that leachates generated from all 16 sludges did not contain concentrations of metals, cyanides and nitrate/nitrite which exceed the limits of a TDGR 9.3 dangerous material.

This report recommends that in future, larger sample volumes should be collected to undertake the analysis performed in this study. The report also recommends that procedures for the measurement of oil and grease and water contents in amine, glycol and sulfinol sludges should be developed. In addition, it is recommended that the classification of the sludges as either hazardous or non-hazardous, should be based on a case-by-case, site specific sampling and analytical program.

TABLE OF CONTENTS

SECTION			PAGE
ACKNOWLEDGEMENTS			i
EXECUTIVE SUMMARY			iii
TABLE OF CONTENTS			vi
LIST OF TABLES			viii
1.0	INTRODUCTION		1
2.0	METHODOLOGY		6
	2.1	Review of Existing Data	13
	2.2	Field Sampling Program	15
	2.3	Laboratory Analytical Program	17
	2.4	Laboratory Quality Control Procedures	20
	2.5	Data Compilation	23
3.0	RESULTS		25
	3.1	Physical and Chemical Characteristics	25
	3.2	Sampling Reports	26
	3.3	Quality Control	27
	3.4	Laboratory Problems	31
4.0	DISCUSSION		34
	4.1	General Physical and Chemical Characteristics	34
	4.2	Data Quality Assessment	49
	4.3	Sampling Procedure Suitability	51
	4.4	Laboratory Procedure Suitability	52
	4.5	Hazardous and Non-Hazardous Considerations	54
5.0	CONCLUSIONS		62
6.0	RECOMMENDATIONS		64
REFERENCES			65

APPENDICES

APPENDIX A - Project Terms of Reference

APPENDIX B - Physical and Chemical Parameter Data Base

APPENDIX C - Additional Analytical Data

APPENDIX D - Sampling Reports

APPENDIX E - Quality Control Reports

LIST OF TABLES

TABLE	TITLE	PAGE
1	Waste Sludge and Solid Definitions	7
2	Laboratory Analytical Program	19
3	Summary of Analytical Procedures	21
4	Quality Control Program Results-Standard Check Solutions	28
5	Quality Control Program Results-Spiked Samples	29
6	Quality Control Program Results-Duplicate Analysis	30

1.0 INTRODUCTION

In October 1989, David Bromley Engineering (1983) Ltd. (DBEL) was retained by the Canadian Petroleum Association (CPA) and Environment Canada, to undertake Phase I of a study to assess treatment technology options for waste sludges and solids produced by the natural gas processing industry. This phase of the study involved assembling a data base of physical and chemical characteristics for a number of waste sludges and solids generated within the industry. The purpose of undertaking this exercise was to compile a sufficient amount of data to assist with the evaluation of treatment technology options for these waste products. This evaluation will be carried out in Phases II and III of the study at a later date.

The original scope of work for the project as referenced in the Terms of Reference for the project (see Appendix A) requested that a total of twenty-one (21) sludges be considered in the project. This list of sludges was developed from the Phase I Report associated with the CPA Waste Management Study (Wotherspoon and Associates, 1988), which identified eighty-six (86) waste products common to the upstream petroleum industry. A listing of these twenty-one (21) sludges and solids is as follows:

1. Flare Knock-Out Drum Sludge
2. Cooling Tower Sludge
3. Process Floor Drain Sludge
4. DEA Amine Sludge

5. MEA Amine Sludge
6. Digestor Sludge
7. Filter Backwash Pond Sludge
8. Flare Pit Sludge
9. Glycol Sludge
10. Inlet Separator Sludge
11. Lime Sludge
12. Neutralized Sulphur Pond Sludge
13. Process Pond Sludge
14. Sulfinol Sludge
15. Un-neutralized Sulphur Pond Sludge
16. Water Treatment Sludge
17. Water Treatment Sludge
18. Closed Water Drain Tank Sludge
19. Fractionator Bottom Sludge
20. Treater Bottom Sludge
21. DIPA Amine Sludge

As the project progressed, and as discussions with plant operators were undertaken, it became apparent that five (5) of the sludges (Caustic Spent Sludge, Closed Water Drain Tank Sludge, Fractionator Bottom Sludge, Treater Bottom Sludge and DIPA Amine Sludge) could be eliminated from the list. Reasons for this were as follows:

i) Caustic Spent Sludge

It was felt that this sludge could generally be classified as a water treatment sludge.

ii) Closed Water Drain Tank Sludge

This sludge was considered to be synonymous with a Process Floor Drain Sludge.

iii) Fractionator Bottom Sludge

It was felt that this sludge was not common to gas processing operations.

iv) Treater Bottom Sludge

This sludge was felt to be more common to oil production operations than gas processing operations.

v) DIPA Amine Sludge

This sludge was considered to be synonymous with Sulfinol Sludge.

Because of this, the scope of the project was changed to consider only sixteen (16) waste sludges and solids. This was reviewed and approved by the project steering committee.

This report presents the results of the study and summarizes its findings. Section 2.0 outlines the methodology used to obtain the data, and compile the data base. Because a significant amount of the data was obtained from a field sampling and laboratory analytical program,

detailed descriptions of the procedures used to collect and analyze the samples are presented in this section. Particular emphasis is placed on outlining the quality control procedures used in the laboratory.

Section 3.0 of the report presents the results associated with the study. Results presented include a summary of the physical and chemical characteristics of each sludge; a summary of statistical parameters associated with the data collected; descriptions of the sampling procedures used to obtain the individual sludge samples; results of the laboratory quality control program; and a summary of the problems encountered during the laboratory analysis of the waste materials.

The results of the study are then discussed in Section 4.0. Subjects addressed in this discussion are as follows:

1. The quality of the data.
2. An assessment of the physical and chemical characteristics of the sludges as they relate to treatment technology selection and classification relative to the Alberta Hazardous Waste Regulation.
3. The suitability of the sampling procedures used in this study.
4. The suitability of the laboratory procedures used in this study.

Based on the discussion of the above, conclusions and recommendations are developed within this section, and are then formally presented in Sections 5.0 and 6.0 respectively.

2.0 METHODOLOGY

The data base was assembled using a combination of information obtained from both a review of existing data, and a comprehensive field sampling and laboratory analytical program. However, prior to obtaining any information, it was necessary to first define the sludges being considered in the project. Because of the variations in processes and configurations within natural gas processing facilities, a standardized nomenclature for waste materials has not been developed. As such, it was necessary to develop definitions for the 16 waste sludges and solids being considered in order to facilitate future treatment technology evaluations.

A list of definitions and commonly used synonyms for the 16 waste sludges and solids is presented in Table 1. For the most part, these definitions have been adapted from those contained in the CPA Petroleum Industry Waste Management Study Phase II report (Wotherspoon and Associates and DBEL, 1989). These definitions were then used when reviewing previous studies, and when discussing sample collection procedures with plant operating staff.

It was also necessary to select the parameters to be included in the data base prior to collection of the data. Selection of these parameters was based on identifying those physical and chemical parameters which would be required to evaluate treatment technology options. Through discussions and meetings with the project steering committee, the members of

TABLE 1 - WASTE SLUDGE AND SOLIDS DEFINITIONS

SLUDGE	DEFINITION	SYNONYMS
1. Flare Knock-Out Sludg	This waste includes those liquids and sludges found in separation facilities, both upstream of and in gas plants.	---
2. Cooling Tower Sludge	This waste includes accumulated sludges in cooling tower sumps and wet wells.	---
3. Process Floor Drain Sludge	This waste includes sludge which accumulates in floor drains, vaults, manholes and sumps throughout the plant. It is generally associated with the plant sewer systems.	Sump Sludge, Building Drain Sludge
4. DEA Amine Sludge	This waste includes reclaimer bottom and leaf filter sludges from gas plants using DEA processes for gas sweetening.	Reclaimer Bottom Sludge, Leaf Filter Sludge
5. MEA Amine Sludge	This waste includes reclaimer bottom and leaf filter sludges from gas plants using MEA processes for gas sweetening.	Reclaimer Bottom Sludge, Leaf Filter Sludge
6. Digestor Sludge	This waste includes all sludges from anaerobic or aerobic digestion processes used in biological wastewater treatment in gas plants.	Bio-Sludge
7. Filter Backwash Pond Sludge	This waste is specific to gas plant facilities with dedicated backwash water collection systems.	Process Pond Sludge
8. Flare Pit Sludge	This waste includes all sludges which accumulate in the bottom of flare pits.	---
9. Glycol Sludge	This waste includes all sludges found on glycol filter systems and in rebollers.	---
10. Inlet Separator Sludge	This waste includes the sludge found in the inlet separator located at the front end of the plant. It is generally produced during turnaround operations.	---
11. Lime Sludge	This waste is associated with gas plant blowdown water. It is found in facilities where lime is used for water softening.	Water Treatment Sludge
12. Neutraiized Sulphur Pond Sludge	This waste includes sludge from the bottom of ponds dedicated to neutralization of low pH runoff water from sulphur blocks.	Runoff Pond Sludge, Process Pond Sludge
13. Process Pond Sludge	This waste includes sludges from various wastewater storage, holding and evaporation ponds. The flow to these ponds is the combination of wastewater, surface drainage and blowdown water.	---
14. Sulfinol Sludge	This waste includes reclaimer bottom and leaf filter sludges from gas plants using sulfinol process for gas sweetening.	Reclaimer Bottom Sludge, Leaf Filter Sludge
15. Un-Neutralized Sulphur Pond Sludge	This waste includes sludges from pond dedicated to the collection of low pH runoff water from sulphur blocks.	---
16. Water Treatment Sludge	This waste is generated in raw water clarification operations. It does not include sludge from combined softening and solids removal operations.	---

(C:\LOTUS\2213\GP-TAB01.WK1)

which represent the CPA, Environment Canada, Alberta Environment and the ERCB, it was decided to include the following parameters in the data base. The rationale used for the selection of these parameters is identified below.

1. Parameter(s): Biochemical Oxygen Demand (BOD_5), Total Organic Carbon (TOC), Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), Nitrate (NO_3^-), Sulfide, Sulphate (SO_4^{2-})

   Rationale: Can be used to assess the potential for biological treatment and /or land application.

2. Parameter(s): Total Suspended Solids (TSS), Volatile Suspended Solids (VSS)

   Rationale: Can be used to assess various mechanical dewatering techniques. It should be noted that this parameter was only compiled for digestor sludges.

3. Parameter(s): % Solids, % Water, Particle Size Distribution (% Sand, Silt and Clay)

   Rationale: Can be used to assess the potential for various mechanical dewatering techniques.

4. Parameter: Oil and Grease

Rationale: Can be used to assess both oil recovery and dewatering techniques. In addition, provides some indication of whether the waste is hazardous based on TDGR Class 9.2 if it's concentration exceeds 100 mg/kg.

5. Parameter: British Thermal Unit (Btu) Content

Rationale: Can be used to assess the potential for incineration.

6. Parameter(s): Total Sulphur, Soluble Ions (Calcium, Magnesium, Sodium, Potassium, Chloride), Electrical Conductivity

Rationale: Can be used to assess the potential for land application.

7. Parameter: Specific Gravity

Rationale: Can be used to assess the potential for mechanical separation(eg/ flotation) and dewatering techniques.

8. Parameter: pH

Rationale: Can be used to assess land and biological treatment options. In addition, it provides some indication of whether or not the waste is hazardous or non-hazardous based on TDGR Class 8,

Corrosive Materials if the pH is less than 2.0 or greater than 12.0 (Fernandes, 1989).

9. Parameter: Flashpoint

Rationale: Can be used to classify the waste as hazardous or non-hazardous based on TDGR Class 3, Flammable Liquid, if the measured flashpoint is less than 61°C.

10. Parameter: Flammability

Rationale: Can be used to classify the waste as hazardous or non-hazardous based on TDGR Class 4, Flammable Solids, if the waste will combust spontaneously.

11. Parameter: Free Liquid

Rationale: Used to determine whether or not the waste is a liquid or a solid and hence, can be used in evaluating the use of landfilling as a disposal option.

12. Parameter: Leachable Metals (Arsenic, Barium, Boron, Cadmium, Chromium, Lead, Mercury, Selenium), Leachable Cyanide, Leachable Nitrate/Nitrite

Rationale: Can be used to determine whether or not the waste is hazardous based on TDGR Class 9.3, Leachable Wastes. It should be noted that the analyses conducted on the leachate did not encompass all of the parameters required to fully assess the TDGR 9.3 classification. Parameters which were not tested include PCB's and a number of other organic compounds (predominately pesticides). These parameters were not tested as it was felt that their occurrence in the waste sludges and solids would be on a site specific basis.

13. Parameter: Chromium

Rationale: Used to determine whether or not the waste is a landfillable hazardous waste based on the Alberta Hazardous Waste Regulation. This parameter was only measured in cooling tower sludges since chromium compounds are often used in the cooling water treatment process. In addition, this parameter provides some indication of whether or not the waste is hazardous based on TDGR Class 9.2, it's concentration exceeds 100 mg/kg.

It should be noted that a number of the parameters (ie/ flashpoint, flammability, leachable metals, leachable cyanides, leachable nitrate/nitrite) were selected in order to provide an

indication of whether or not the wastes are hazardous based on the Alberta Hazardous Waste Regulation. While not specifically required to evaluate treatment technology options, these parameters are useful since the regulations impose certain requirements which may impact on the way in which the waste is treated. For example, liquid hazardous wastes containing the following components may not be landfilled in Alberta:

i) Free Cyanides > 1000 mg/kg

ii) Arsenic ≥ 500 mg/kg

iii) Cadmium ≥ 100 mg/kg

iv) Chromium (Cr^{+6}) ≥ 500 mg/kg

v) Lead ≥ 500 mg/kg

vi) Mercury ≥ 100 mg/kg

vii) Nickel ≥ 134 mg/kg

viii) Selenium ≥ 100 mg/kg

ix) Thallium ≥ 130 mg/kg

Therefore should one particular sludge be classified as a hazardous liquid waste and contained one or more of the above listed components at concentrations exceeding the specified concentrations, there may be some incentive to consider dewatering as a treatment option in order to permit landfill disposal.

2.1 Review of Existing Data

A significant amount of physical and chemical characterization work has previously been carried out on gas plant sludges. As such this work was reviewed, and information was extracted for inclusion in the data base. Details about the projects from which the data was extracted are as follows:

1. Project: CPA Petroleum Industry Waste Management Study, Phase II: Inventory Characterization

   Authors: Paul Wotherspoon and Associates Ltd., DBEL

   Date: March 1989

   Synopsis: A survey of CPA member companies was undertaken to estimate waste volumes and to compile data on physical and chemical characteristics of 85 upstream petroleum industry wastes.

2. Project: CPA Petroleum Industry Waste Management Study, Phase III

   Authors: Paul Wotherspoon and Associates Ltd., DBEL

   Date: June 1989

   Synopsis: Additional physical and chemical characterization data on 26 priority wastes identified in the Phase II report, was obtained through an exhaustive literature search and a CPA member company survey.

3. Project: Petroleum Waste Management: Amine Process Sludges, University of Calgary Masters Degree project.

Author: Carol Boyle

Date: April 1990

Synopsis: A study was undertaken to evaluate waste management options for DEA and MEA sludges. Within this study, sludge samples were obtained and chemical analyses of these sludges were carried out.

4. Project: CPA Gas Plant Sludge Characterization Study Phase IIA - Analysis of Gas Plant Sludges for Cyanide and Total Elemental Contents (Draft Report)

Author: Alberta Research Council

Date: June 1989

Synopsis: This project involved the development of methods for the analysis of cyanide and the elements Ag, As, B, Ba, Be, Cd, Co, Cr, Cu, Hg, Mn, Mo, Pb, Sb, Se, Ti, V and Zn in gas plant sludges.

5. Project: CPA Gas Plant Sludge Characterization Study Phase IIB - Verification and Optimization of Organic Contaminant and Toxicity Testing Analytical Procedures for Determining the Characteristic and Environmental Significance of Natural Gas Processing Plant Waste Sludges (Draft Report).

Author: Western Research

Date: June 1988

Synopsis: This project involved developing both improved methods of screening waste sludges for organic analysis, and effective aquatic and terrestrial toxicity tests.

In addition, it was learned that the American Petroleum Institute was undertaking a similar study on petroleum industry waste characteristics. However, attempts to obtain preliminary copies of this work were unsuccessful and hence, this information could not be included in the data base.

2.2 Field Sampling Program

A total of 51 sludge samples were obtained from 21 different gas plants throughout Alberta. In general, 3 samples of each sludge were taken - 1 sample from 3 different plants. However, because process pond sludges represent the largest waste treatment and disposal problem within the petroleum industry, 8 process pond sludge samples were obtained. In addition, only 1 digestor sludge sample was obtained as there appears to be only 1 digestor in operation within the province.

Samples were collected by both DBEL and operations staff at the various plants. Standardized sampling techniques were used as much as possible, recognizing that there are

considerable variations in the locations of the sludges within the different plants. In general, the following procedures were followed:

1. Onsite meetings were held with plant staff prior to sampling. Where samples were obtained by the plant staff, telephone conversations were used to ensure that plant personnel understood both the type of sludge required, and the sampling procedures to be followed.

2. Samples were collected in glass bottles. This was based on the recommendation of the analytical laboratory (Chemex Labs Alberta Inc.) retained for the project. Where samples were collected by plant operations staff, glass sample bottles were sent to the plant by DBEL. In most cases they were used.

3. A minimum sample volume of 500 mL was collected. This again was based on the recommendation of Chemex.

Where possible, composite samples were made by combining samples taken over a large area and from different depths.

5. Pond samples were collected using a vacuum pump apparatus. This proved to be an effective method for obtaining sludge samples in ponds up to 6.0 m in depth and was very conducive to making composite samples.

6. Samples taken from vaults or sumps were obtained using the vacuum pump apparatus. In cases where the sludge was too dense, core samples were obtained by driving a PVC pipe into the sludge and extracting the core at the surface.

7. In shallow sumps or pits, grab samples were taken using a plastic bottle attached to a pole. A number of samples were taken and combined to form a composite sample.

8. Where drains were sampled, or when sludge volumes were low, samples were collected directly in the glass sample bottle. In these cases a composite sample was not made.

9. Samples were stored in an ice-filled cooler after collection to retain their characteristics.

10. Samples were usually sent to the laboratory within 1 day of collection.

11. All equipment was thoroughly cleaned prior to reuse to avoid cross contamination.

2.3 Laboratory Analytical Program

Sample preparation at the laboratory was carried out in accordance with CPA procedures (Monenco Consultants Ltd., 1987). Upon arrival at the laboratory, samples were thoroughly

shaken and then allowed to decant for 24 hours. Supernatant was then removed and analysis of the samples was performed.

The analytical program used by Chemex is summarized in Table 2. In general, all samples were analyzed for all of the parameters identified in Section 2.0, with the following exceptions:

1. TSS and VSS were only analyzed on digestor sludges as these were the only sludges in which biological solids were anticipated.

2. BOD_5, TOC, TP, TKN, NO_3^-, Sulfide and SO_4^{2-} analyses were not carried out on neutralized sulphur pond, lime, un-neutralized sulphur pond and water treatment sludges as it was felt that these sludges were not candidates for biological treatment.

3. Flashpoint and flammability analyses were not carried out on neutralized sulphur pond, lime, un-neutralized sulphur pond, cooling tower and water treatment sludges as it was felt that the risk of flammability associated with these sludges was relatively low.

4. Leachate tests were only carried out on wastes which were not classified as hazardous based on flashpoint, flammability or corrosivity (pH).

TABLE 2 – LABORATORY ANALYTICAL PROGRAM

SLUDGE TYPE	# OF SAMPLES			PARAMETERS ANALYZED																						
	TOTAL	SOUR PLANTS	SWEET PLANTS	BOD5	TOC	TP	TKN	NITRATE	SULFIDE	SULPHATE	TSS	VSS	% SOLIDS	% WATER	OIL & GREASE	BTU CONTENT	TOTAL S	S.G.	pH	ROUTINE CATIONS/ANIONS (1)	PARTICLE SIZE DISTRIBUTION	ELECTRICAL CONDUCTIVITY	FLASHPOINT/FLAMMABILITY (2)	LEACHATE (3)	FREE LIQUIDS	Cr
1. FLARE KNOCK–OUT	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
2. COOLING TOWER	3	3	1	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X		X	X	X
3. PROCESS FLOOR DRAIN	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
4. DEA AMINE	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
5. MEA AMINE	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
6. DIGESTOR	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
7. FILTER BACKWASH POND	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
8. FLARE PIT	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
9. GLYCOL SYSTEM	3	3	1	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
10. INLET SEPARATOR	3	3	1	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
11. LIME	3	3	0										X	X	X	X	X	X	X	X	X	X		X	X	
12. NEUT. SULPHUR POND	3	3	0										X	X	X	X	X	X	X	X	X	X		X	X	
13. PROCESS POND	8	8	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
14. SULFINOL	3	3	0	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
15. UN–NEUT. SULPHUR POND	3	3	0										X	X	X	X	X	X	X	X	X	X		X	X	
16. WATER TREATMENT	3	3	0										X	X	X	X	X	X	X	X	X	X		X	X	

(C:\LOTUS\2213\6\P-TABLE.WK1)

(1) Routine Cations/Anions include Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-} and HCO_3^{-}.

(2) Leachate tests to be carried out on sludges not classified under TDGR classes 3, 4 and 8 based on the flashpoint, flammability and pH analyses. Parameters to be analyzed include As, Ba, B, Cd, Cr, Pb, Hg, Se, CN and NO_2/NO_3.

(3) Flashpoint test was carried out on liquids. Flammability test was carried out on solids.

Analytical protocol was carried out in accordance with the procedures listed in Table 3. These procedures were reviewed by the project steering committee prior to undertaking the analysis.

2.4 Laboratory Quality Control Procedures

A formalized quality control program was used by Chemex for this project. This program involved carrying out the following three checks on the analytical techniques and equipment used:

1. Standard check solutions having known concentrations of specific parameters were prepared by Chemex's quality control department, and analyzed by the technician(s) performing the sludge analysis. The results were then compared to theoretical concentrations and expressed in terms of percent recovery. This component of the quality control program was used to confirm that the technician(s) were performing the analysis correctly, and that the analytical equipment was functioning properly.

2. Sludge samples were "spiked" with known amounts of specified compounds and were then analyzed. The results were then compared to the theoretical "spiked" concentrations, and expressed in terms of percent recovery. Again, the purpose of this check was to confirm that the technician(s) were performing the analysis correctly

TABLE 3 – SUMMARY OF ANALYTICAL PROCEDURES

PARAMETER	METHOD
BOD Biochemical Oxygen Demand	Sludge/sediment is diluted in distilled water and BOD conducted according to NAQUADATE002. Seed will be added and five day BOD measured with the Winkler procedure. BOD will be reported as mg/g wet sludge. Detection Limit = 1 mg/g
COD Chemical Oxygen Demand	Sludge/sediment is diluted in distilled water and COD conducted according to NAQUADATE004 - a semi-automated colorimetric procedure utilizing H_2SO_4-Ag_2SO_4 and $K_2Cr_2O_7$ heated to 150 °C for 2 hours. Colorimetric determinations made at 600nm. Detection Limit = 5 mg/g
TOC Total Organic Carbon	Total organic carbon will be determined using the Walnly-Black technique. A reflux method using H_2SO_4 and reduction of potassium dichromate. Detection Limit = 0.1 weight %
TP Total Phosphorous	Semi-automated - Persulfate digestion. NAQUADATP1550. Sample is ground to 120 mesh, digested with sulphuric acid, potassium persulfate. Phosphorous is determined using ICP-AES at 178 nm. Detection limit = 1 mg/g
TN Total Kjeldahl Nitrogen	Total Kjeldahl Nitrogen - sample is digested in conc H_2SO_4 potassium persulfate and perchloric acid. The recovered ammonia is analyzed on an autoanalyzer system, utilizing the Berthelot reaction and measured at 660nm. Detection Limit = 1 mg/g
NO_3 Nitrate	Sludge/sediment is diluted in distilled water and extracted on a mechanical shaker for 4 hours. The solution is filtered through 0.45 micro cellulose acetate paper and the soluble nitrate is measured by Ion Chromatography. Detection Limit = 0.003 ppm
Sulfide	The original sludge/sediment is diluted in distilled water and this solution is analyzed using Iodometric method (titration with Standard Sodium thiosulphate). Detection Limit = 0.01 ppm
SO_4 Sulphate	Prepared as per nitrate, the filtered solution is analyzed for sulphate utilizing ion chromatography and conductivity detection. Detection Limit = 1 ppm
% Solid/ % Water	If sample is high in oil, as determined by Dean-Stark procedure, the sludge is placed in a porous thimble and refluxed in toluene until the filtrate is clear. Separate percent determinations are made on oil, water, solids portions. Detection Limit = 1 ppm
O & G Oil and Grease	Oil and grease is determined utilizing an infrared technique NAQUADATCODE 0403. The sludge is extracted with freon and the extract measured on a infrared spectrophotometer at 2930cm^{-1}. Detection Limit = 1 ppm
TOTAL S Total Sulphur	Performed by Leco Induction furnace. The sample is heated in an induction furnace at 2000 °C. The sulfur dioxide evolved from the oxidation of all sulphur forms is automatically titrated in an iodine-potassium iodate solution. Detection Limit = 0.01% by weight
S.G. Specific Gravity	Carried out on the demoted sludge slurry using a calibrated pycnometer. Detection Limit = 0.01
pH	The pH will be conducted on the original sample or a extracted extract using a pH meter equipped with a pH combination electrode.

TABLE 3 – SUMMARY OF ANALYTICAL PROCEDURES CONTINUED

PARAMETER	METHOD
ROUTINE CATIONS/ANIONS Detection Limits Ca = 0.1 ppm Mg = 0.1 ppm Na = 0.1 ppm K = 0.1 ppm Cl = 0.1 ppm HCO_3 = 0.5 ppm	On a 2:1 extract Cations to be determined include Ca, Mg, Na, K. Calcium and magnesium will be determined by atomic absorption using nitrous oxide/acetylene flame. Sodium and potassium will be measured by flame emission spectroscopy. Alkalinity will be determined by potentiometric titration with H_2SO_4. Anions include SO_4, Cl and HCO_3. The sulphate procedure has been described earlier, Cl will be analysed by ion chromatography and conductivity detection.
PARTICLE SIZE DISTRIBUTION	Particle size will be conducted using the Bouyoucous hydrometer technique and 50 gms of air dried sediment.
E.C. Electrical Conductivity	Conductivity will be measured on extract of slurry or saturated paste utilising a conductivity meter.
FLASHPOINT/ FLAMMABILITY	Flammability will be measured the Pensky-Martens Closed Cup flash point apparatus. The apparatus will be modified for unstirrable solids by performing the same test with the stirrer disconnected.
LEACHATE	The leachate test will be conducted according to the procedure described in "The Canadian General Standards Board Class 9, Miscellaneous Substances CGSB Leachate Extraction Procedure". Test methods used will be in accordance with US EPA SW-846 "Test Methods for Evaluating Solid Waste".
FREE LIQUID	Free liquid will be determined utilising the US EPA SW-846 paint filter test technique.
B.T.U.	Will be determined using a calorimeter to measure heating value (BTU).
CYANIDE	Chloramine-T, pyridine barbituric acid colourimetry on an auto-analyser. Sample is acidified, distilled and buffered, then reacted with chloramine-T and a pyridine-barbituric acid reagent. The colour is measured spectrophotometrically at 570nm and compared with standard KCN solutions. Detection Limit = 0.001 ppm
ARSENIC and SELENIUM	Semi-automated flameless atomic absorption. Manual digestion of samples with sulfuric and nitric acids, followed by $NaBH_4$ reduction and measurement at 193nm and 196nm respectively. Detection Limit = 0.0002 ppm for both
BARIUM, BORON, CADMIUM, CHROMIUM and LEAD	By inductively coupled argon plasma emission spectroscopy. The sample is aspirated: emission is measured at 455.4nm, 249.7nm, 228.8nm, 267.7nm and 220.3nm respectively and compared with that of standard solutions. Detection Limits: Ba = 0.01; B = 0.01 ppm; Cd = 0.001 ppm; Cr = 0.001 ppm; and Pb = 0.01 ppm.
MERCURY	Flameless atomic absorption on an automalyser. Sample is mixed with $KMnO_4$ and conc. H_2SO_4, then digested at 105 °C. This solution is then mixed with hydroxylamine sulphate and NaCl, the $SnSO_4$. The mixture is sparged with air, the liquid removed by a gas separator and the air flow, containing Hg vapour, is then passed through an absorption cell. Absorbance is measured spectrophotometrically at 253.7nm and compared to standard mercury solutions. Detection Limit = 0.01 ppb
TSS Total Suspended Solids	Gravimetric determination. The pre-weighed sludge is filtered through a Whatman GF/C filterpaper which has also been pre-weighed. The filterpaper containing the suspended solids is oven dried at 105 °C for 1 hour and then weighed.
VSS Volatile Suspended Solids	The oven dried filter from T.S.S. above is placed in a muffle furnace at 550 °C for 1 hour and the loss in weight reported as volatile suspended solids NAQUADAT10407.

and that the analytical instruments were functioning properly. In addition, this check can also be used to identify interferences in the analytical technique.

3. Duplicate analyses of the samples were performed to assess the reproducibility of the analytical techniques. The differences between the results were statistically compared with Chemex's historical data to determine if the reproducibility of the results was acceptable.

2.5 Data Compilation

Upon completion of the analytical work, results were input to Lotus 1-2-3 spreadsheets along with the data obtained from previous studies. The following statistical parameters were then calculated for each parameter analyzed:

- Mean;
- Minimum Value;
- Maximum Value; and
- Standard Deviation.

It is recognized that the mean and standard deviation calculations were generally based on a very small sample population, and hence their statistical significance is likely very

questionable. However, it was decided to include these parameters in the report as they provide an indication of the variability associated with the results.

3.0 RESULTS

The results of this study include the following:

1. A summary of the physical and chemical characteristics for each of the 16 sludge types.

2. A report outlining the procedures followed in obtaining each sample and a diagram illustrating where in the plant the sample was taken from.

3. A set of quality control reports that were prepared by the laboratory that analyzed the sludge types.

4. An account of the problems encountered by the laboratory during the analytical process.

3.1 Physical and Chemical Characteristics

Data obtained from the review of existing data and the sampling/analytical program is presented in Appendix B for each sludge. Three sheets summarizing the physical and chemical properties have been provided for each sludge. These are as follows:

1. A summary of the physical and chemical properties based on the sampling/analytical program.

2. A summary of the physical and chemical properties based on the review of the previous studies.

3. A summary of the statistical parameters associated with the data presented in 1. and 2. Values for the mean, minimum value, maximum value and standard deviation value are presented.

In addition, a summary of the physical and chemical properties not analyzed in the laboratory program, but identified in the review of existing data is presented in Appendix C for each sludge.

3.2 Sampling Reports

Appendix D presents sampling reports and schematic diagrams illustrating the locations within the plant where the samples were obtained for each sludge.

3.3 Quality Control

Detailed results of the quality control program are presented in Appendix E. Summaries of the quality control program results are presented in Tables 4, 5 and 6. Table 4 presents a summary of the percent recoveries associated with the analysis of the standard check solutions. As shown in this table measured concentrations ranged from 85.2% to 125.0 % of the theoretical concentrations of the parameters in solution.

Table 5 summarizes the percent recoveries associated with the analysis of the spiked samples. As shown, measured concentrations of the spiked parameters ranged from 84.0% to 118.2% of the actual concentration of the parameter added.

Table 6 presents a synopsis of the results from the duplicate analysis checks. This table indicates that, where Chemex had a sufficient historical data base to draw statistical conclusions, all duplicate analyses performed were within the acceptable confidence limits of 95%. However, it should be noted that Chemex had sufficient historical data from which to draw conclusions for only 14 of the 40 parameters considered in this project.

A review of Appendix E and Tables 4, 5 and 6 indicates that the quality control program did not encompass the analysis of the following parameters:

- BOD
- Particle Size Distribution

TABLE 4 – QUALITY CONTROL PROGRAM RESULTS – STANDARD CHECK SOLUTION

PARAMETER	STANDARD CHECK SOLUTION (% RECOVERY)					
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5	SAMPLE #6
Total Organic Carbon	105	98	102			
Total Phosphorous	93.8	85.2				
Total Kjeldahl Nitrogen	98.2	110	105.3			
Soluble Ions (Total Sample)						
Calcium	100	105	90			
Magnesium	110	97	97.5			
Sodium	107	106	108			
Potassium	103	102	111			
Chloride	95	96.2	98.7			
Sulphate	98.3	103	98.3			
Nitrate as N	104					
Sulfide	100	94.2				
Leachate Analysis						
Arsenic	100	112.5	125	112.5		
Barium	97.1	96.6	93.6			
Boron	96.1	96.7	88.2			
Cadmium	100	99.3	98.1			
Chromium	97.7	95.3	92.3			
Lead	102.5	104.3	97.2			
Mercury	109	97	110			
Selenium	113	77.7	111	112.5		
Cyanide	107	102.3	97.6	100	98	100

(C:\LOTUS\2213\F-TAB04.WK1)

TABLE 5 – QUALITY CONTROL PROGRAM RESULTS – SPIKED SAMPLES

PARAMETER	SPIKED SAMPLE (% RECOVERY)					
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5	SAMPLE #6
Total Kjeldahl Nitrogen	108	100	98			
Soluble Ions (Total Sample)						
Chloride	100	101	100.7			
Sulphate	100.7	100	100			
Nitrate as N	96.5					
Leachate Analysis						
Arsenic	100	103.9	100	94.2	98.2	101.3
Barium	100	98.9	94.9			
Boron	103.5	100	118.2			
Cadmium	97.2	115	96.3			
Chromium	97.7	90.9	102.5			
Lead	91.6	112.5	100.5			
Mercury	87.6	105	101	98.2		
Selenium	102	97.7	105	90	98.1	104
Cyanide	100	100	96	87	96.4	100

(C:\LOTUS\2213\GP-TAB05.WK1)

TABLE 6 - QUALITY CONTROL PROGRAM - DUPLICATE SAMPLE ANALYSIS

PARAMETER	DUPLICATE ANALYSIS ACCEPTABILITY						
	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5	SAMPLE 6	SAMPLE 7
Total Kjeldahl Nitrogen	YES	YES	YES	YES			
Total Sulphur	N.A.	N.A.	N.A.	N.A.			
pH	YES	YES					
Electrical Conductance	YES	YES	YES				
Soluble Ions							
Calcium	N.A.	N.A.	N.A.	N.A.			
Magnesium	N.A.	N.A.	N.A.	N.A.			
Sodium	N.A.	N.A.	N.A.	N.A.			
Potassium	N.A.	N.A.	N.A.	N.A.			
Chloride	YES	YES	YES	YES			
Sulphate	YES	YES	YES				
Bicarbonate	N.A.	N.A.	N.A.				
Nitrate as N	N.A.						
Sulfide	N.A.	N.A.					
Leachate Analysis							
Arsenic	YES	YES	YES	YES	YES	YES	YES
Barium	YES	YES	YES				
Boron	YES	YES	YES				
Cadmium	YES	YES	YES	YES			
Chromium	YES	YES	YES				
Lead	YES	YES	YES	YES			
Mercury	YES	YES	YES	YES	YES		
Selenium	YES	YES	YES	YES	YES	YES	YES
Cyanide	YES	YES	YES	YES	YES	YES	

(C:\LOTUS\22\SQP-TABS.WK1)

"N.A." Indicates that Chemex Labs Alberta Inc. did not have sufficient in-house historical data to assess whether the differences between duplicate analyses were within statistically acceptable limits.

- TSS	- Flashpoint/Flammability
- VSS	- Btu Content
- Oil and Grease	- Specific Gravity
- % Solids and Water	- Free Liquids

The reasons for not implementing the quality control program for the analysis of these parameters are as follows:

1. It is difficult to prepare standard check solutions for these parameters.
2. It is difficult to prepare spiked solutions with these parameters.
3. Chemex did not have a large enough in-house historical data base to support the statistical analysis associated with the duplicate analysis check. Duplicate analysis could have been carried out for these parameters, but an evaluation of their statistical acceptability was not possible.

3.4 Laboratory Problems

The following problems were encountered by Chemex during the analysis of the sludges:

1. Some of the samples were in three distinct phases (oil, water and solids) and others had oil adhered to the sample container. Even after mixing, it was difficult to obtain a homogenous sub-sample which is necessary for some chemical analysis.

2. Biological Oxygen Demand (BOD) was difficult to determine for some of the sludges because it is necessary to have a homogenous sample and the oil in the sludge was immiscible.

3. Many of the samples were high in sulfide content and therefore the Iodometric Titration procedure was used to determine sulfide concentration rather than the Ion Chromatography method originally proposed.

4. Problems were encountered in analyzing some of the sulfinol, glycol, inlet separator and amine samples for water content. The cause of this problem is that sulfinol, glycol and amine are water soluble and formed an emulsion with the toluene that is used in the Dean-Stark extraction procedure.

5. Problems were also encountered in performing the oil and grease analysis on the sulfinol, glycol and amine samples as the samples were soluble in both freon and methylene chloride extractions.

6. In a number of cases, a 500 mL sample was insufficient in size to complete the analysis for particle size distribution (ie/ % sand, silt and clay). This was generally found in samples having low solids concentrations (< 6%). As such, it was not physically possible to carry out the hydrometer analysis.

7. In two cases (two Flare Knock-Out Sludges), a 500 mL sample was insufficient in size to complete the analyses for oil, water and solids content. This was due to experimentation with methodologies for oil and water analyses. Unsuccessful attempts were made to obtain additional samples from the same sources to redo the analyses. It should be noted that four oil, water and solids analyses are available from previous studies.

4.0 DISCUSSION

Within this section, the results presented in Section 3.0 are discussed. Items discussed are as follows:

1. The general physical and chemical characteristics of each sludge.
2. The quality of the data.
3. The suitability of the sampling procedures used in the study.
4. The suitability of the laboratory procedures used in the study.

4.1 General Physical and Chemical Characteristics

i) Flare Knock-Out Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and four analysis taken from previous studies.

Table 1 in Appendix B indicates that this sludge typically exists in a liquid form and has variable organic contents (TOC's ranged from 9.1 to 48.1% by weight). Solids concentrations ranged from 0.6 to 26.1%. Oil and water concentrations were quite variable with concentrations ranging from 5100 to 438000 mg/kg and 1.4 to 96.2% found.

The biodegradable portion of the organic material is relatively low (BOD's ranged from 341 to 452 mg/kg) but considerable amounts of nutrients appear to be available (TP and TKN concentrations ranged from 7.5 to 18.4 mg/kg and 20.5 to 1200 mg/kg respectively). Btu contents appear to be highly variable (0 - 8740 Btu/lb).

Specific gravities are slightly less than 1.0 (0.84 -1.0). Electrical conductance and pH appear to be highly variable (760 - 25200 μmhos/cm and 4.9 - 9.5 respectively). Two of the three samples had flashpoints below 61°C and hence, would be classified as a TDGR Class 3, Flammable Liquids. Metals, cyanide and nitrate/nitrite concentrations in the one leachate test performed were found to be minimal.

ii) Cooling Tower Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and five analyses taken from previous studies.

Table 2 in Appendix B indicates that these sludges tend to exist in a liquid form. They consist predominately of solids and/or water, and contain small amounts of oil (< 900 ppm). The organic component appears to be quite biodegradable (BOD_5's ranged from 143 to 1441 ppm) and high

concentrations of nutrients generally are present. Since there is not a large organic component to this sludge, the BTU content is low (183 - 1030 Btu/lb). The specific gravity tends to be slightly higher than 1.0. pH appears to be slightly acidic to slightly basic and electrical conductance is between 1000 and 12,000 μmhos/cm. Leachates generated from these sludges do not appear to contain significant amounts of metals, cyanides or nitrates/nitrites. Chromium concentrations in the sludge were highly variable (0.002 - 23750 ppm).

iii) Process Floor Drain Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and five analyses taken from previous studies.

Table 3 in Appendix B suggests that these sludges have highly variable oil, water and solids contents, and hence can exist in either the liquid or solid phase. The biodegradable portion of the organic component appears to be relatively high (BOD_5's ranged from 1880 to 5690 ppm). Nutrient concentrations are quite variable as TP and TKN concentrations ranged from 13.7 to 4680 ppm and 28 to 2190 ppm respectively. BTU contents (114 - 7687 Btu/lb) are quite variable and appear to be proportional to the amount of oil present. Specific gravities are generally greater than 1.0. pH ranges from slightly acidic to moderately basic, and electrical conductance appears to be

highly variable. Leachates do not appear to contain significant concentrations of metals, cyanides or nitrates/nitrites.

Based on the flashpoint and flammability tests, none of the sludges would be classified as a TDGR class 3 or 4 Flammable Liquid or Solid.

iv) DEA Amine Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and five analyses taken from previous studies.

Table 4 in Appendix B suggests that these sludges can exist in either the solid or liquid phase and generally have high organic components (TOC's ranged from 19.4 to 52.3%), although the solids concentrations are highly variable (0.07 - 33.92%). Analytical problems encountered by the laboratory resulted in only one analysis being completed for oil and water content. However, the one analysis completed, combined with the results from previous studies indicates that oil and grease contents can range from 0.19 to 24.5%, and water contents vary from 31.8 to 41.6%. Considerable nitrogen is present (TKN's ranged from 4400 to 107000 ppm), which is understandable as amines are nitrogen-based compounds. The sludges appear to have relatively consistent BTU contents (9442 - 11732 Btu/lb). Specific gravities are slightly greater

than 1.0. The sludges are generally quite basic (pH ranges from 7.3 - 12.1), and electrical conductance is relatively consistent (6000 - 17,000 μmhos/cm). Based on the results of the flashpoint and flammability tests, none of the sludges would be classified as a TDGR Class 3 or 4 Flammable Liquid or Solid. Again, leachates do not appear to contain significant amounts of metals, cyanides or nitrates/nitrites.

v) MEA Amine Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and seven analyses taken from previous studies.

Table 5 in Appendix B suggests that these sludges can exist in either the solid or liquid form and have total organic carbon values ranging from 1.79 to 14.3%. Oil, water and solids contents were highly variable as values ranged from 0.04 to 9900 ppm, 30.8 to 60.8% and 0.008 to 43.6% respectively. Considerable nitrogen is present as TKN values ranged from 14800 to 89000 ppm, whereas minimal concentrations of phosphorus are present (<0.5 - 43 ppm TP). Btu contents ranged from 435 to 4700 Btu/lb while BOD values were quite high (4040 - 10900 ppm).

Specific gravities varied from 0.97 to 1.24. The sludges were generally quite basic as pH's as high as 12.6 were reported. Electrical conductivity was highly variable (1900 - 13900 μmhos/cm).

Based on the flashpoint/flammability tests, none of the samples would be classified as a TDGR Class 3 or 4 Flammable Liquid or Solid. Leachates do not appear to contain significant quantities of metals, cyanides or nitrates/nitrites.

vi) Digestor Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of one sample and obtained for this project and four analyses taken from previous studies.

Table 6 in Appendix B suggests that this sludge consists predominately of water, with some biological solids present. The pH is slightly basic, and the electrical conductivities are relatively consistent (2040 - 5968 μmhos/cm). Based on the flammability tests, the sludge is not flammable. Leachate generated from the sludge does not appear to contain significant amounts of metals, cyanides or nitrates/nitrites. Since there was only one analysis performed on this sludge, it is difficult to make conclusions about its characteristics. However, since there appears to be only one digestor

operating at a gas plant in Alberta, the compilation of a large data base of physical and chemical characteristics is not likely required for the management of this sludge.

vii) Filter Backwash Pond Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project. No analyses were obtained from previous studies.

Table 7 in Appendix B indicates that the physical and chemical properties of this sludge are highly variable. The sludge was found to exist in both liquid and solid forms, and oil, water and solids content varied significantly between samples. Both the biodegradable component of the sample and the BTU contents varied considerably, with little correlation existing between the two parameters. pH ranged from slightly acidic (6.49) to slightly basic (8.05) and electrical conductivity was highly variable (840 - 5100 μmhos/cm). One of the samples was found to have a flashpoint < 61°C and hence, would be classified as a TDGR Class 4 Flammable Liquid, whereas the other two samples were not found to be flammable solids. Leachates do not appear to contain significant amounts of metals, cyanides or nitrates/nitrites.

viii) Flare Pit Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and four analyses taken from previous studies.

Table 8 in Appendix B shows that this sludge typically exists as a solid and has a variable organic content (TOC's ranged from 0.48 to 17.5%). Oil and water concentrations appear to be highly variable with concentrations ranging from 0.2 - 26.3% and 9.1 - 30.7% respectively. Both the Biochemical Oxygen Demand and the Btu content are highly variable as values from 1095 to 9860 ppm and 610 to 4067 Btu/lb were measured. The specific gravity is typically greater than 1.0, with values of 1.2 to 1.7 measured. The pH indicates a slightly basic material, with a range of 7.8 to 8.8 observed. Electrical conductivity is highly variable as values of 600 to 20800 umhos/cm were reported. No indications of flammability were detected. Again, leachates generated from these sludges do not appear to contain significant amounts of metals, cyanides or nitrate/nitrite.

ix) Glycol System Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and four analyses taken from previous studies.

Table 9 in Appendix B indicates that this sludge typically exists in a liquid form and is highly organic (TOC's ranged from 25.7 to 50.2% by weight). Solids concentrations range from 3.7 to 12.6%. Conclusive information on oil and water concentrations was not obtained as a result of analytical problems. Based on results from previous studies, it would appear that water concentrations are relatively low (0.5 - 2.5%).

The Biochemical Oxygen Demand is highly variable (294 - 5790 ppm) and significant amounts of nutrients appear to be present (TP and TKN concentrations ranged from 8.4 to 18.9 ppm and 58 to 842 ppm respectively). Btu contents appear to be relatively consistent (3100 - 5000 Btu/lb).

Specific gravities are slightly greater than 1.0 (1.08 -1.14). Electrical conductance and pH appear to be highly variable (100 - 1280 μmhos/cm and 3.8 - 8.9). Two of the three samples had flashpoints below 61°C and hence, would be classified as TDGR Class 3, Flammable Liquids. Metals, cyanide and nitrate/nitrite concentrations in the leachate are minimal.

x) Inlet Separator Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and three analyses taken from previous studies.

Table 10 in Appendix A indicates that this sludge can exist in either the solid or liquid form. It is characterized by highly variable oil, water and solids contents as values ranged from 0.08 to 72.7%, 2.9 to 97.7% and 1.2 to 88.8% respectively. It should be noted that analytical problems were encountered with the analysis of water contents for two of the samples as the oil in the sample formed an emulsion with the toluene used in the Dean Stark method. Biological Oxygen Demands were also highly variable as values of 375 to 8130ppm were observed, whereas Btu contents were relatively consistent (1159 - 1470 Btu/lb).

The specific gravity of the sludge is relatively variable (1.0 to 1.9) as are pH (6.64 - 9.2) and electrical conductivity (870 - 10600 μmhos/cm). Flashpoint and flammability tests indicate that one of the sludge samples would be classified as a TDGR Class 4 Dangerous Good. Leachates generated from this sludge have low concentrations of metals, cyanide and nitrate/nitrite.

xi) Lime Sludge

The discussions of the physical and chemical characteristics of this sludge is based on the analysis of three sludge samples obtained for this project and one analysis taken from a previous study.

This sludge (see Table 11 in Appendix B) appears to be present in both solid and liquid forms. It is characterized by variable solids and water contents (8.0 - 73% and 25 - 92% respectively) and relatively low concentrations of oil. Btu content is relatively low (400 -900 Btu/lb) in all cases.

The sludge is heavier than water (specific gravities range from 1.05 to 1.7) and has a high pH ranging from 9.0 to 10.0. Electrical conductivity is relatively low (540 - 570 umhos/cm). Leachates generated from this sludge have low metals, cyanide and nitrate/nitrite concentrations.

xii) Neutralized Sulphur Pond Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and two analyses taken from previous studies.

This sludge (see Table 12 in Appendix B) is present in both solid and liquid forms. It is characterized by variable solids and water contents (37 - 74% and

25 - 63% respectively) and relatively low concentrations of oil (0.06 - 1.2%). Btu content was found to be quite variable (23 - 1300 Btu/lb).

The sludge is significantly heavier than water (specific gravities range from 1.3 to 1.8) and has a slightly basic pH ranging from 7.2 to 9.2. Electrical conductivity is relatively consistent (4700 - 6100 umhos/cm). Leachates generated from this sludge have low metals, cyanide and nitrate/nitrite concentrations.

xiii) Process Pond Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of eight samples obtained for this project and nine analyses taken from previous studies.

Table 13 in Appendix B shows that this sludge typically exists as a solid, as 6 of the 8 samples analyzed did not yield any free liquids when subjected to the free liquids test. Oil and water concentrations appear to be highly variable with concentrations ranging from 0.05 to 21.3% and 7.5 to 82.0% measured respectively. The Biochemical Oxygen Demand and Btu Contents are highly variable as values ranging from 8 to 18500 ppm and 0 to 4653 Btu/lb were found. The specific gravity is typically greater than 1.0, with values of 1.15 to 1.9 measured. The pH indicates a slightly acidic to basic material, with a range of 6.9 to 9.3 observed. Electrical conductivity is highly variable as values

of 860 to 12940 umhos/cm were reported. No indications of flammability were detected. Again, leachates generated from these sludges do not appear to contain significant amounts of metals, cyanides or nitrate/nitrite.

xiv) Sulfinol Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and four analyses taken from previous studies.

Table 14 in Appendix B indicates that this sludge typically exists in a liquid form and has a highly variable organic content (TOC's ranged from 10.3 to 49.5% by weight). Solids concentrations range from 0.06 to 51.9%. Conclusive information on oil and water concentrations was not obtained as a result of analytical problems (only one water analysis and two oil analyses were completed). Based on results from the completed analyses and previous studies, it would appear that water concentrations are highly variable (0.4 - 92.3%), and that oil contents range from 6950 to 95200 ppm.

The biodegradable portion of the organic material is highly variable (BOD's ranged from 50 to 10950 ppm). Significant amounts of nutrients appear to be present (TP and TKN concentrations ranged from 11.5 to 790 ppm and 1900

to 101000 ppm respectively). Very large concentrations of nitrogen are present and are attributable to the sulfinol in the sludge. Btu contents appear to be highly variable (514 - 10782 Btu/lb).

Specific gravities are slightly greater than 1.0 (1.11 -1.2). Electrical conductance appears to be somewhat variable (1370 - 6980 umhos/cm) and pH ranges from 6.1 to 10.4. None of the three samples analyzed were found to be flammable. Metals, cyanide and nitrate/nitrite concentrations in the leachate are minimal.

xv) Un-Neutralized Sulphur Pond Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and four analyses taken from previous studies.

This sludge (see Table 15 in Appendix B) is present in both solid and liquid forms. It is characterized by relatively consistent solids and water contents (57 - 84% and 16 - 45% respectively) and relatively low concentrations of oil (0.001 - 1.0%). Btu content was found to be quite variable (0 - 1668 Btu/lb).

The sludge is significantly heavier than water (specific gravities range from 1.18 to 1.91) and has an acidic to slightly basic pH ranging from 3.4 to 7.2.

Electrical conductivity is relatively consistent (2100 - 6100 umhos/cm). Leachates generated from this sludge have low metals, cyanide and nitrate/nitrite concentrations.

While not a part of the proposed analytical program, one of the samples was tested for flammability as a result of it's high sulphur content (46.1% by weight), and was found to be flammable. The other two samples had low sulphur contents (0.09, 2.92%) and as such, were not tested for flammability as per the analytical program.

xvi) Water Treatment Sludge

The discussion of the physical and chemical characteristics of this sludge is based on the analysis of three samples obtained for this project and four analyses taken from previous studies.

This sludge (see Table 16 in Appendix B) appears to be present in both solid and liquid forms. It is characterized by variable solids and water contents (1.3 - 70% and 30 - 45% respectively). Low oil and grease concentrations were found in two of the samples (< 197 ppm) whereas a higher concentration was found in the third (10700 ppm). Btu content is relatively consistent (954 - 2431 Btu/lb).

The sludge is heavier than water (specific gravities range from 1.16 to 1.59) and has a variable pH ranging from 5.7 to 10.1. Electrical conductivity is relatively low (280 - 1020 umhos/cm). The sludge is not flammable. Leachates generated from this sludge have low metals, cyanide and nitrate/nitrite concentrations.

4.2 Data Quality Assessment

It is difficult to assess the quality of the data obtained through the review of previous work. Quality Control Programs were not reported for Phases II and III of the CPA Waste Management Study, nor were they reported in the Amine Process study. Quality Control Programs were implemented in Phases IIA and IIB of the CPA Gas Plant Sludge Characterization Study, however the parameters being considered were different from those considered in this project. As such, there has been no attempt to undertake an assessment of the quality of this data.

The quality of the data obtained from the sampling and analytical program can be assessed through a review of the quality control program results, as presented in Tables 4, 5 and 6.

As previously discussed, Table 4 presents a summary of the amount of a parameter measured, expressed as a percentage of the amount of the parameter added to a standard solution. Results indicated that measured concentrations ranged from 85.2% to 125.0% of

the theoretical concentrations. Whether or not this is acceptable is very subjective, however given that feasible treatment technologies must function over a relatively wide range of influent conditions, this range of variability is likely reasonable.

Table 5 presents a synopsis of the results of the spiked sample analysis. As shown on this table, measured concentrations of spiked parameters ranged from 87.0% to 118.2% of the actual concentration of the spiked parameters. Since "spiking" is used to confirm the suitability of the analytical procedures and the absence of interferences, these results suggest that the analytical procedures were generally accurate within 15-20%. Again, while somewhat subjective, this range of variability would appear to be acceptable for an assessment of treatment technologies.

Table 6 presents the results of the duplicate analysis. As shown on this table, all of the duplicates performed met Chemex's in-house standards for reproducibility, and hence, it can be concluded that the data is acceptable for these parameters. However, it should be realized that duplicate analyses were not performed for the following parameters:

- BOD_5
- TOC
- TP
- % Water
- Oil & Grease
- T.S.S.
- Particle Size Distribution
- S.G.
- Flashpoint/Flammability
- Free Liquids
- V.S.S.

Whether or not it can be concluded that the results for the above parameters are reliable is again very subjective. Chemex noted that obtaining a homogenous mixture of some of the oily sludges was difficult due to the immiscible nature of the oil. However, all of the parameters tested in duplicate samples proved to be within acceptable concentration limits. As such, it is felt that the data is acceptable from a reproducibility perspective.

Because all three quality control checks (standard check solutions, spiked samples and duplicate samples) appeared to yield acceptable results, it is concluded that the data is acceptable for an assessment of treatment technologies for the waste sludges.

The only concern with respect to the quality of the data relates to the inability to consistently determine oil and water contents for some of the amine, glycol, inlet separator and sulfinol sludges. While sufficient information is likely available to assess incineration, biological treatment, land farming and land filling for these sludges, the lack of complete information on the oil and water contents may make it difficult to evaluate mechanical separation technologies for these sludges.

4.3 Sampling Procedure Suitability

Based on our discussions with the steering committee, the sampling procedures used in the project appeared to be acceptable. Problems related to insufficient sample volumes for the analysis of particle size distribution were encountered for sludges having low solids

concentrations. In addition, in retrospect, Chemex would have preferred to have larger sample volumes to facilitate duplicate analysis, and experimentation with alternate analytical techniques. As such, they recommend collecting a minimum of 2.0 L of sample for the analysis of the parameters carried out in this study.

4.4 Laboratory Procedure Suitability

Given the favourable results of the standard solution and spiked sample checks, it appears that the laboratory procedures used to analyze the following parameters were acceptable:

- TOC
- TP
- TKN
- Ca
- Mg
- Na
- K
- Cl
- SO_4
- NO_3
- Sulfide
- CN
- As
- Se
- Hg
- Ba
- B
- Cd
- Cr
- Pb

Since checks were not performed on the remaining parameters, it is difficult to conclude that the techniques used to analyze these parameters were correct. Since problems were encountered in determining the oil and water content for some of the amine, glycol, inlet separator and sulfinol sludges, it is evident that the methods employed were not acceptable forsome of these sludges. Whether or not a technique should be developed is debatable, since the knowledge of these parameters is only required for the preliminary evaluation of mechanical dewatering technologies. Since these technologies would have to be pilot plant-

tested prior to implementing a full-scale dewatering system, the determination of these parameters may not be required.

It is felt that the procedures used to analyze those parameters not checked within the Quality Control Program (BOD, % water, % solids, electrical conductivity, oil and grease, particle size distribution, flashpoint, flammability, TSS, VSS, BTU content, SG, and free liquid) are relatively well-proven procedures, and hence were acceptable for this project. With the exception of the analysis for oil and water content of the amine, glycol and sulfinol sludges, no applications were identified where the procedures could not be used. This opinion was supported by Chemex.

4.5 Hazardous and Non-Hazardous Considerations

The chemical analytical results for each sludge type were reviewed to assess their hazardous nature, based on the Alberta Hazardous Waste Regulation [Hazardous Chemicals Act (R.S.A. 1980, c. H-3, as amended)].

It should be emphasized however, that this assessment was based only on the classification of the wastes relative to the following TDGR classes.

- Class 3 Flammable Liquids
- Class 4 Flammable Solids
- Class 8 Corrosives
- Class 9.2 Environmentally Hazardous Substances
- Class 9.3 Leachable Substances

No attempt was made to classify the wastes relative to Class 5 - Oxidizing Substances, Class 6 - Poisonous and Infectious Substances and Class 7 - Radioactive Materials. In addition, a complete assay of analyses was not undertaken to definitively classify the wastes relative to Classes 9.2 (where oil and grease was used as an indicator of the presence of a number of Class 9.2 materials) and 9.3 (where only 10 out of a total of 31 parameters were measured in the leachate).

A summary of the assessment of each sludge is as follows:

i) Flare Knock-Out Sludge

Two out of the three samples analyzed had flashpoints < 61°C. As such, these samples would be classified as Class 3 Dangerous Goods under the T.D.G.R., and hence would also be classified as hazardous waste. In addition, the high oil content associated with the waste (concentrations of up to 438000 ppm were measured) could also cause it to be classified as a hazardous waste if it were shown that a Class 9.2 Dangerous Good (e.g., almost any aromatic hydrocarbon) was present at concentrations exceeding 0.01% by mass.

ii) Cooling Tower Sludge

This is potentially a hazardous waste if it could be shown that it contained a Class 9.2 Dangerous Good (e.g., chromium compounds, aromatic hydrocarbons) at concentrations exceeding 0.01% by mass. This is a possibility as chromium and oil and grease concentrations of up to 2370 ppm and 859 ppm respectively were found.

iii) Process Floor Drain Sludge

This could be classified as a hazardous waste if it could be shown that the oil content contained a Class 9.2 Dangerous Good (e.g., almost any aromatic hydrocarbon) at concentrations exceeding 0.01% by mass. Given the

relatively high oil content (oil and grease concentrations up to 2690 ppm were measured) this is a distinct possibility.

iv) DEA Amine Sludge

This could be classified as a hazardous waste if it could be shown that the oil content contained a Class 9.2 Dangerous Good at concentrations exceeding 0.01% by mass. In addition, the high pH associated with the waste (one sample had a pH of 12.1) could result in a hazardous classification based on a T.D.G.R. Class 8, Corrosive Material classification.

v) MEA Amine Sludge

This is likely a hazardous waste, since MEA is listed as a Class 8, Corrosive Material under the T.D.G.R. However, it should be noted that based on the analyses carried out and the data reviewed, none of the MEA sludge analyses had pH's exceeding 12.0.

vi) Digestor Sludge

Based on the results this does not appear to be a hazardous waste. However, given the presence of microorganisms in the sludge, it could potentially be classified as a Class 6 - Poisonous and Infectious Substance.

vii) Filter Backwash Pond Sludge

One of the three samples had a flashpoint < 61°C, and hence would be classified as hazardous based on a T.D.G.R. Class 3, Flammable Liquid classification. In addition, the sludge has a high oil and grease content (> 2150 ppm), and hence could be classified as hazardous if it was shown that the oil content contained a Class 9.2 Dangerous Good at concentrations exceeding 0.01% by mass.

viii) Flare Pit Sludge

This could be classified as a hazardous waste if it could be shown that the oil content contained a Class 9.2 Dangerous Good (e.g., almost any aromatic hydrocarbon) at concentrations exceeding 0.01% by mass. Given the relatively high oil content (concentrations of oil and grease up to 263000 ppm) were measured), this is a distinct possibility.

ix) Glycol Sludge

Two of the three samples analyzed had flashpoints < 61°C. As such, these samples would be classified as a Class 3 Dangerous Good under the T.D.G.R., and hence would also be classified as a hazardous waste.

x) Inlet Separator Sludge

This could be classified as a hazardous waste if it could be shown that the oil content contained a Class 9.2 Dangerous Good (e.g., almost any aromatic hydrocarbon) at concentrations exceeding 0.01% by mass. Given the relatively high oil content (concentrations of oil and grease up to 4100 ppm were measured), this is a distinct possibility.

xi) Lime Sludge

None of the three samples had particularly high oil and grease contents (0.9, 39.9 and 884 ppm), and it is unlikely that a Class 9.2 Dangerous Good is present at concentrations exceeding 0.01% by mass. In general this sludge should be relatively hydrocarbon-free, and hence is likely non-hazardous.

xii) Neutralized Sulphur Pond Sludge

One of the three samples had a relatively high oil and grease content (1.2%), and hence could be classified as hazardous if it was shown that a Class 9.2 Dangerous Good was present at concentrations exceeding 0.01% by mass. However, in general this sludge should be relatively hydrocarbon-free, and hence is likely non-hazardous.

xiii) Process Pond Sludge

This could be classified as a hazardous waste if it could be shown that the oil content contained a Class 9.2 Dangerous Good (e.g., almost any aromatic hydrocarbon) at concentrations exceeding 0.01% by mass. Given the relatively high oil content, this is a distinct possibility.

xiv) Sulfinol Sludge

This could be classified as a hazardous waste if it could be shown that the oil content contained a Class 9.2 Dangerous Good (e.g., almost any aromatic hydrocarbon) at concentrations exceeding 0.01% by mass. Given the relatively high oil content (oil and grease concentrations up to 95200 ppm were measured), this is a distinct possibility.

xv) Un-Neutralized Sulphur Pond Sludge

One of the samples was found to be a flammable solid, and hence would be classified as hazardous based on a T.D.G.R. Class 4 Flammable Solid classification. This likely resulted from the sample having a very high sulphur content (46.1% by weight). As such, this sludge could potentially be classifed as a hazardous waste.

xvi) Water Treatment Sludge

One of the samples had a relatively high oil and grease content (10700 ppm), and hence could be classified as a hazardous waste if it could be shown that the oil content contained a TDGR Class 9.2 Dangerous Good (eg., almost any aromatic hydrocarbon) at concentrations exceeding 0.01% by mass. In general, this sludge should be relatively hydrocarbon free as evidenced by the low organic content of the other two samples (62 and 197 ppm oil and grease). However, given the high oil content in the one sample, it is recommended that this sludge be classified as potentially hazardous.

In summary, the following classifications are proposed for the 17 sludges:

1. Most Likely Hazardous
   - Flare Knock-Out Sludge
   - MEA Sludge
   - Glycol Sludge

2. Potentially Hazardous
   - Cooling Tower Sludge
   - Process Floor Drain Sludge
   - DEA Amine Sludge
   - Filter Backwash Pond Sludge

- Flare Pit Sludge
- Inlet Separator Sludge
- Process Pond Sludge
- Sulfinol Sludge
- Digestor Sludge
- Un-Neutralized Sulphur Pond Sludge
- Water Treatment Sludge

3. Not Likely Hazardous
   - Lime Sludge
   - Neutralized Sulphur Pond Sludge

However, in spite of this summary, it is recommended that the hazardous/non-hazardous classification be based on site-specific analysis, given the considerable variance in the concentrations of the various parameters.

5.0 CONCLUSIONS

1. In general, the quality of the data obtained from the sampling and analytical program appears to be acceptable for the assessment of treatment technology options for the sludges.

2. Problems with the analysis of oil and grease for some of the amine, glycol and sulfinol sludges resulted in incomplete data being obtained relative to this parameter.

3. Problems with the analysis of water content for some of the amine, glycol, inlet separator and sulfinol sludges resulted in incomplete data being obtained relative to this parameter.

4. In general, the analytical procedures used to measure the parameters considered in the project, appeared to be acceptable. An exception to this was the methods used to analyze oil and grease in some of the amine, glycol and sulfinol sludges, as these sludges were found to be soluble in both the freon and methylene chloride used in the oil and grease analysis. Another exception was the method used to analyze water content in some of the amine, glycol, inlet separator and sulfinol sludges where the amine, glycol, sulfinol and oil in the inlet separator sludge was found to be soluble in the toluene used in the Dean-Stark method used for determining water content.

4. Leachates generated from the sludges considered in this study did not contain significant concentrations of metals, cyanides and nitrate/nitrite relative to the limits specified for a TDGR Class 9.3, Leachable Waste.

6.0 RECOMMENDATIONS

1. A minimum of two (litres) of material should be collected for sludge analyses similar to that undertaken in this project.

2. Because of the variability of physical and chemical properties for the different sludges, hazardous and non-hazardous classifications should be based on a case-by-case, site specific sampling and analytical program.

3. Additional work on the development of reliable methods for the measurement of oil and grease and water content in amine, glycol, inlet separator and sulfinol sludges should be undertaken.

REFERENCES

1) Alberta Research Council (1989), "Analysis of Gas Plant Sludges for Cyanide and Total Elemental Contents", Canadian Petroleum Association Publication.

2) Boyle, C.A. (1990), "Petroleum Waste Management: Amine Process Sludges", Masters Degree Thesis, Faculty of Environmental Design, University of Calgary, Calgary, Alberta.

3) Monenco Consultants Ltd. (1987), "Gas Plant Sludge Characterization: Pilot Program", Canadian Petroleum Association Publication.

4) Western Research (1988), "Verification and Optimization of Organic Contaminant and Toxicity Testing Analytical Procedures for Determining the Characteristic and Environmental Significance of Natural Gas Processing Plant Waste Sludges (Draft Report)", Canadian Petroleum Association Publication.

5) Wotherspoon and Associates (1988), "The Canadian Petroleum Association, Industry Waste Survey", Canadian Petroleum Association Publication, September 1988.

6) Wotherspoon and Associates, David Bromley Engineering (1983) Ltd. (1989), "Petroleum Industry Waste Management Study, Phase II: Inventory Characterization", Canadian Petroleum Association Publication.

7) Wotherspoon and Associates, David Bromley Engineering (1983) Ltd. (1989), "Petroleum Industry Waste Management Study, Phase III: Priority Waste Characterization", Canadian Petroleum Association Publication.

APPENDIX A

PROJECT TERMS OF REFERENCE

SCOPE OF WORK

Assessment of Technology Options for Treatment of Waste Sludges Produced by the Natural Gas Processing Industry.

Background

Since 1984, the Canadian Petroleum Association and Environment Canada have jointly supported research on the development of a methodology for determining the characteristics and estimating the environmental implications of waste sludges from natural gas processing plants. The next step is to examine potential treatment options for natural gas processing waste sludges and solids; comparing the effectiveness, environmental implications and total cost of each. Unfortunately, the waste sludge inorganic and organic characterization data generated to date is not the type of information required by engineers to assess treatment technology options. Additional basic physical/chemical data on waste sludges from natural gas processing will likely have to be generated through a further waste characterization program.

This research project will be of considerable benefit and relevance to both industry and government as a number of Western Canada gas plants are scheduled for decommissioning over the next few years. Each plant operator will have to deal with their residual wastes during plant site decommissioning (ie. comparison of treatment technologies and cost on a local and regional scale). This project will better prepare industry for this eventuality.

Project Objectives

Phase I - to generate a physical/chemical waste sludge characteristics database essential for the treatment technology evaluation.

Phase II - to identify and assess all potential treatment technology options for treating specific waste sludge generated by the natural gas processing industry.

Phase III - to demonstrate the effectiveness and determine the real cost of top ranked waste sludge treatment technology at Alberta gas plant locations.

Phase I Scope of Work

The project contractor will be required to conduct the following:

- identify the physical/chemical parameters of gas plant sludges required for the evaluation and selection of high potential waste sludge treatment technology.
- collect and review existing physical/chemical information for the following gas plant waste sludges:

Ref: RKJ89803

- caustic spent sludge
- flare knockout sludge
- cooling tower sludge
- closed water drain tank sludge
- process floor drain tank sludge
- DEA amine system sludge
- DIPA amine system sludge
- MEA amine system sludge
- biotreater digestor sludge
- filter backwash pond sludge
- flare pit sludge
- fractionator bottom sludge
- glycol system sludge
- inlet separator sludge
- lime sludge
- neutralized sulphur pond sludge
- process pond sludge
- sulfinol system sludge
- sulphur block runoff pond sludge (unneutralized)
- treater bottom sludge
- water treatment sludge

- although the review of information available for the above sludge may supply sufficient data for the assessment of technology treatment potential for some sludges, for the purposes of this bid, outline the cost for the sampling and physical/chemical analysis of the sludges listed above.

Project Management

- monthly technical and financial status reports will be submitted to the project technical steering committee (TSC) co-chairman.

- at least three meetings with the TSC will be required during the project. All meetings will be held in Calgary.

- members of the TSC will assist the contractor during the project by providing relevant reports available and assistance in arranging gas plant sampling visits.

Proposal Requirements

Bidders are required to supply the following:

- technical scope of work
- project schedule
- outline of relevant company experience
- outline of experience of project team members
- breakdown of project cost by person and task
- list of per diem rates for project team member

Revised: July 27/89

APPENDIX B

PHYSICAL AND CHEMICAL PARAMETER DATA BASE

TABLE B1 – FLARE KNOCK–OUT SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	452	19200	341
Total Organic Carbon (weight %)	9.1	48.1	12.3
Total Phosphorous (ppm)	18.4	14	7.51
Total Kjeldahl Nitrogen (ppm)	20.5	1200	1160
% Solids	I.S.	0.6	I.S.
% Water	I.S.	1.44	I.S.
Oil & Grease (ppm)	I.S.	438000	I.S.
BTU Content (BTU/LB) as received basis	1181	8740	0
Total Sulphur (weight %)	0.21	0.53	0.08
Specific Gravity	0.97	0.84	1
pH	4.9	9.07	9.5
Electrical Conductance (umhos/cm)	2680	760	25200
Particle Size (% Sand)	I.S.	I.S.	I.S.
Particle Size (% Silt)	I.S.	I.S.	I.S.
Particle Size (% Clay)	I.S.	I.S.	I.S.
Free Liquid (%)	96	100	25
Flashpoint (Deg. C)	100	6.5	41
Flammability	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	80	4	120
Magnesium (ppm)	4.9	2.4	12.2
Sodium (ppm)	68.7	9.16	10200
Potassium (ppm)	1.56	0.78	39.1
Chloride (ppm)	96	1.3	153
Sulphate (ppm)	1294	2.8	204
Bicarbonate (ppm)	0	12.8	26200
Nitrate as N (ppm)	0.272	0.04	0.4
Sulfide (ppm)	20	3.6	308
Leachate Analysis			
Arsenic (mg/L)	0.0005	N/A	N/A
Barium (mg/L)	0.03	N/A	N/A
Boron (mg/L)	1.09	N/A	N/A
Cadmium (mg/L)	0.001	N/A	N/A
Chromium (mg/L)	0.001	N/A	N/A
Lead (mg/L)	0.02	N/A	N/A
Mercury (ug/L)	0.1	N/A	N/A
Selenium (mg/L)	<0.0002	N/A	N/A
Cyanide (mg/L)	0.001	N/A	N/A
Nitrate/Nitrite as N (mg/L)	0.014	N/A	N/A

A.P.–Analytical Problems / I.S.–Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B1 – FLARE KNOCK–OUT SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	ANALYSIS 1	ANALYSIS 2	ANALYSIS 3	ANALYSIS 4
Biological Oxygen Demand (ppm)				
Total Organic Carbon (weight %)			39.5	
Total Phosphorous (ppm)				
Total Kjeldahl Nitrogen (ppm)				
% Solids	10.5	3.3	8.1	26.10
% Water	88.9	96.2	91.4	39.1
Oil & Grease (ppm)	6500	5100	5300	34800
BTU Content (BTU/LB) as received basis				
Total Sulphur (weight %)				
Specific Gravity				
pH			5.53	
Electrical Conductance (umhos/cm)				
Particle Size (% Sand)				
Particle Size (% Silt)				
Particle Size (% Clay)				
Free Liquid (%)				
Flashpoint (Deg. C)				
Flammability				
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)				
Magnesium (ppm)				
Sodium (ppm)				
Potassium (ppm)				
Chloride (ppm)				
Sulphate (ppm)	14000		1300	
Bicarbonate (ppm)				
Nitrate as N (ppm)				
Sulfide (ppm)		1650	9800	42000.00
Leachate Analysis				
Arsenic (mg/L)				
Barium (mg/L)				
Boron (mg/L)				
Cadmium (mg/L)				
Chromium (mg/L)				
Lead (mg/L)				
Mercury (ug/L)				
Selenium (mg/L)				
Cyanide (mg/L)				
Nitrate/Nitrite as N (mg/L)				

(C:\LOTUS\221SEP-APR91.WK1)

A.P.–Analytical Problems / I.S.–Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B1 – FLARE KNOCK–OUT SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	6664.33	341	19200	8864.17
Total Organic Carbon (weight %)	27.25	9.1	48.1	16.86
Total Phosphorous (ppm)	13.30	7.51	18.4	4.47
Total Kjeldahl Nitrogen (ppm)	793.50	20.5	1200	546.84
% Solids	9.72	0.6	26.1	8.90
% Water	63.41	1.44	96.2	37.25
Oil & Grease (ppm)	97940.00	5100	438000	170405.50
BTU Content (BTU/LB) as received basis	3307.00	0	8740	3871.85
Total Sulphur (weight %)	0.27	0.08	0.53	0.19
Specific Gravity	0.94	0.84	1	0.07
pH	7.25	4.9	9.5	2.05
Electrical Conductance (umhos/cm)	9546.67	760	25200	11096.30
Particle Size (% Sand)	N.A.	N.A.	N.A.	N.A.
Particle Size (% Silt)	N.A.	N.A.	N.A.	N.A.
Particle Size (% Clay)	N.A.	N.A.	N.A.	N.A.
Free Liquid (%)	73.67	25	100	34.45
Flashpoint (Deg. C)	49.17	6.5	100	38.61
Flammability				
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	68.00	4	120	48.11
Magnesium (ppm)	6.50	2.4	12.2	4.16
Sodium (ppm)	3425.95	9.16	10200	4790.04
Potassium (ppm)	13.81	0.78	39.1	17.88
Chloride (ppm)	83.43	1.3	153	62.57
Sulphate (ppm)	3360.16	2.8	14000	5347.01
Bicarbonate (ppm)	8737.60	0	26200	12347.78
Nitrate as N (ppm)	0.24	0.04	0.4	0.15
Sulfide (ppm)	8963.60	3.6	42000	15170.04
Leachate Analysis				
Arsenic (mg/L)	0.0005	0.0005	0.0005	0.0000
Barium (mg/L)	0.0300	0.0300	0.0300	0.0000
Boron (mg/L)	1.0900	1.0900	1.0900	0.0000
Cadmium (mg/L)	0.0010	0.0010	0.0010	0.0000
Chromium (mg/L)	0.0010	0.0010	0.0010	0.0000
Lead (mg/L)	0.0200	0.0200	0.0200	0.0000
Mercury (ug/L)	0.1000	0.1000	0.1000	0.0000
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	0.0010	0.0010	0.0010	0.0000
Nitrate/Nitrite as N (mg/L)	0.0140	0.0140	0.0140	0.0000

A.P.–Analytical Problems / I.S.–Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B2 – COOLING TOWER SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	1441	1080	143
Total Organic Carbon (weight %)	1.8	2.5	0.2
Total Phosphorous (ppm)	2780	23300	245
Total Kjeldahl Nitrogen (ppm)	1730	5930	155
% Solids	33	16.1	3.1
% Water	66.2	83.4	96.8
Oil Content (ppm)	859	116	17.8
BTU Content (BTU/LB) as received basis	1030	917	183
Total Sulphur (weight %)	0.13	0.34	0.04
Specific Gravity	1.22	1.15	1.01
pH	7.94	7.13	7.26
Electrical Conductance (umhos/cm)	1320	2800	1800
Particle size % Sand	15	60	I.S.
Particle size % Silt	50	30	I.S.
Particle size % Clay	35	10	I.S.
Free Liquid (%)	2	4	96
Flashpoint (Centigrade)	N.T.	N.T.	N.T.
Flammability	N.T.	N.T.	N.T.
Chromium (ppm)	2580.0	1920.0	N.T.
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	160	400	240
Magnesium (ppm)	49	98	73
Sodium (ppm)	41.2	32.1	22.9
Potassium (ppm)	8.6	28.2	10.9
Chloride (ppm)	37.4	78	41.4
Sulphate (ppm)	16.8	1044	732
Bicarbonate (ppm)	774	719	170
Nitrate as N (ppm)	0.528	0.226	0.328
Sulfide (ppm)	1070	750	80
Leachate Analysis			
Arsenic (mg/L)	0.018	0.12	0.012
Barium (mg/L)	0.93	0.25	0.47
Boron (mg/L)	0.07	0.08	0.02
Cadmium (mg/L)	<0.001	<0.001	<0.001
Chromium (mg/L)	0.25	0.027	0.007
Lead (mg/L)	0.02	0.01	0.01
Mercury (ug/L)	0.1	0.1	0.1
Selenium (mg/L)	<0.0002	<0.0002	<0.0002
Cyanide (mg/L)	<0.001	<0.001	<0.001
Nitrate/Nitrite as N (mg/L)	0.026	0.011	0.016

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B2 – COOLING TOWER SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA				
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5
Biological Oxygen Demand (ppm)					
Total Organic Carbon (weight %)					
Total Phosphorous (ppm)					
Total Kjeldahl Nitrogen (ppm)	0.33	0.14			
% Solids			4.2	5.3	2.1
% Water					
Oil Content (ppm)	8.9	0.1			
BTU Content (BTU/LB) as received basis					
Total Sulphur (weight %)					
Specific Gravity					
pH	7.8	6.58	7.48	7.84	7.56
Electrical Conductance (umhos/cm)			11900	11400	9600
Particle size % Sand					
Particle size % Silt					
Particle size % Clay					
Free Liquid (%)					
Flashpoint (Centigrade)					
Flammability					
Chromium (ppm)	0.9	0.0	7150.0	23750.0	18000.0
Soluble Ions (On Total Sample Basis)					
Calcium (ppm)	180	126			
Magnesium (ppm)	43.1	38.4			
Sodium (ppm)	115	120			
Potassium (ppm)	5.6	5.3			
Chloride (ppm)					
Sulphate (ppm)					
Bicarbonate (ppm)					
Nitrate as N (ppm)					
Sulfide (ppm)	0.42	0.01	9570	8330	22710
Leachate Analysis					
Arsenic (mg/L)					
Barium (mg/L)					
Boron (mg/L)					
Cadmium (mg/L)					
Chromium (mg/L)					
Lead (mg/L)					
Mercury (ug/L)					
Selenium (mg/L)					
Cyanide (mg/L)					
Nitrate/Nitrite as N (mg/L)					

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B2 – COOLING TOWER SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	688.00	143	1441	547.02
Total Organic Carbon (weight %)	1.50	0.2	2.5	0.96
Total Phosphorous (ppm)	8775.00	245	23300	10322.73
Total Kjeldahl Nitrogen (ppm)	1563.09	0.14	5930	2278.84
% Solids	7.98	0	33	10.60
% Water	82.13	66.2	96.8	12.52
Oil Content (ppm)	200.36	0.1	859	331.97
BTU Content (BTU/LB) as received basis	710.00	183	1030	375.49
Total Sulphur (weight %)	0.17	0.04	0.34	0.13
Specific Gravity	1.13	1.01	1.22	0.09
pH	7.45	6.58	7.94	0.42
Electrical Conductance (umhos/cm)	6470.00	1320	11900	4571.41
Particle size % Sand	25.00	0	60	25.50
Particle size % Silt	26.67	0	50	20.55
Particle size % Clay	15.00	0	35	14.72
Free Liquid (%)	34.00	2	96	43.85
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Chromium (ppm)	7628.70	0	23750	8800.55
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	221.20	126	400	96.78
Magnesium (ppm)	60.30	38.4	98	22.30
Sodium (ppm)	66.24	22.9	120	42.28
Potassium (ppm)	11.72	5.3	28.2	8.49
Chloride (ppm)	52.27	37.4	78	18.27
Sulphate (ppm)	597.60	16.8	1044	429.99
Bicarbonate (ppm)	554.33	170	774	272.69
Nitrate as N (ppm)	0.36	0.226	0.528	0.13
Sulfide (ppm)	5313.80	0.01	22710	7521.13
Leachate Analysis				
Arsenic (mg/L)	0.0500	0.012	0.12	0.0496
Barium (mg/L)	0.5500	0.25	0.93	0.2833
Boron (mg/L)	0.0567	0.02	0.08	0.0262
Cadmium (mg/L)	0.0000	0	0	0.0004
Chromium (mg/L)	0.0947	0.007	0.25	0.1101
Lead (mg/L)	0.0133	0.01	0.02	0.0047
Mercury (ug/L)	0.1000	0.1	0.1	ERR
Selenium (mg/L)	0.0000	0	0	0.0000
Cyanide (mg/L)	0.0000	0	0	0.0000
Nitrate/Nitrite as N (mg/L)	0.0177	0.011	0.026	0.0062

(C:\LDTUB\21\3\P-AP\B2.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B3 – PROCESS FLOOR DRAIN SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	5690	1880	2480
Total Organic Carbon (weight %)	18.7	3.7	0.6
Total Phosphorous (ppm)	13.7	4680	57.6
Total Kjeldahl Nitrogen (ppm)	2190	1320	28
% Solids	31.4	73.6	0.5
% Water	55.8	24.7	99
Oil & Grease (%)	12.8	1.7	0.3
BTU Content (BTU/LB) as received basis	7687	1097	114
Total Sulphur (weight %)	5.26	4.59	0.09
Specific Gravity	1.14	1.88	0.99
pH	7.93	8.88	6.31
Electrical Conductance (umhos/cm)	4160	840	7020
Particle Size (% Sand)	27	87	I.S.
Particle Size (% Silt)	69	8	I.S.
Particle Size (% Clay)	4	5	I.S.
Free Liquid (%)	8	0	96
Flashpoint (Deg. C)	N/A	N/A	100
Flammability	no	no	N/A
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	240	72	640
Magnesium (ppm)	24.4	9.8	98
Sodium (ppm)	202	32.1	614
Potassium (ppm)	10.2	3.91	77.4
Chloride (ppm)	8.8	11.8	1400
Sulphate (ppm)	6.2	92	17.2
Bicarbonate (ppm)	0	0	1200
Nitrate as N (ppm)	0.1	1	0.02
Sulfide (ppm)	8800	360	38
Leachate Analysis			
Arsenic (mg/L)	0.0027	0.0086	0.0022
Barium (mg/L)	2.43	0.01	1.29
Boron (mg/L)	0.5	0.05	0.19
Cadmium (mg/L)	<0.001	<0.001	<0.001
Chromium (mg/L)	<0.001	<0.001	0.003
Lead (mg/L)	<0.01	<0.01	0.02
Mercury (ug/L)	0.05	0.25	0.1
Selenium (mg/L)	<0.0002	<0.0002	<0.0002
Cyanide (mg/L)	<0.001	0.007	<0.001
Nitrate/Nitrite as N (mg/L)	0.005	0.05	0.001

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B3 – PROCESS FLOOR DRAIN SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA				
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5
Biological Oxygen Demand (ppm)					
Total Organic Carbon (weight %)			22		
Total Phosphorous (ppm)					
Total Kjeldahl Nitrogen (ppm)			950		
% Solids	15.5		35		
% Water	75.5	53.64	52.4	73.5	80
Oil & Grease (%)	17.5	3.5	1.9	1.7	
BTU Content (BTU/LB) as received basis					
Total Sulphur (weight %)					
Specific Gravity					
pH			8	7.78	7.81
Electrical Conductance (umhos/cm)				4100000	2158000
Particle Size (% Sand)					
Particle Size (% Silt)					
Particle Size (% Clay)					
Free Liquid (%)					
Flashpoint (Deg. C)					
Flammability					
Soluble Ions (On Total Sample Basis)					
Calcium (ppm)		0.001			
Magnesium (ppm)					
Sodium (ppm)					
Potassium (ppm)					
Chloride (ppm)					
Sulphate (ppm)					
Bicarbonate (ppm)					
Nitrate as N (ppm)			0.4		
Sulfide (ppm)					
Leachate Analysis					
Arsenic (mg/L)					
Barium (mg/L)					
Boron (mg/L)					
Cadmium (mg/L)					
Chromium (mg/L)					
Lead (mg/L)					
Mercury (ug/L)					
Selenium (mg/L)					
Cyanide (mg/L)					
Nitrate/Nitrite as N (mg/L)					

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B3 – PROCESS FLOOR DRAIN SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	3350.00	1880	5690	1672.56
Total Organic Carbon (weight %)	11.25	0.6	22	9.24
Total Phosphorous (ppm)	1583.77	13.7	4680	2189.44
Total Kjeldahl Nitrogen (ppm)	1122.00	28	2190	775.60
% Solids	19.50	0	73.6	24.56
% Water	64.32	24.7	99	21.08
Oil & Grease (%)	2.11	0	12.8	4.40
BTU Content (BTU/LB) as received basis	2966.00	114	7687	3362.29
Total Sulphur (weight %)	3.31	0.09	5.26	2.30
Specific Gravity	1.34	0.99	1.88	0.39
pH	7.79	6.31	8.88	0.76
Electrical Conductance (umhos/cm)	1254004.00	840	4100000	1649509.09
Particle Size (% Sand)	38.00	0	87	36.36
Particle Size (% Silt)	25.67	0	69	30.81
Particle Size (% Clay)	3.00	0	5	2.16
Free Liquid (%)	34.67	0	96	43.49
Flashpoint (Deg. C)	33.33	0	100	47.14
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	238.00	0.001	640	247.89
Magnesium (ppm)	44.07	9.8	98	38.60
Sodium (ppm)	282.70	32.1	614	244.32
Potassium (ppm)	30.50	3.91	77.4	33.26
Chloride (ppm)	473.53	8.8	1400	655.11
Sulphate (ppm)	38.47	6.2	92	38.12
Bicarbonate (ppm)	400.00	0	1200	565.69
Nitrate as N (ppm)	0.38	0.02	1	0.38
Sulfide (ppm)	3066.00	38	8800	4056.68
Leachate Analysis				
Arsenic (mg/L)	0.0045	0.0022	0.0086	0.0029
Barium (mg/L)	1.2433	0.01	2.43	0.9885
Boron (mg/L)	0.2467	0.05	0.5	0.1880
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	N/A	N/A	N/A	N/A
Lead (mg/L)	N/A	N/A	N/A	N/A
Mercury (ug/L)	0.1333	0.05	0.25	0.0850
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	N/A	N/A	N/A	N/A
Nitrate/Nitrite as N (mg/L)	0.0187	0.001	0.05	0.0222

(C:\LOTUS\B3-SCP-AP&B.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B4 – DEA AMINE SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	128	0.6	485
Total Organic Carbon (weight %)	25.7	52.3	24.2
Total Phosphorous (ppm)	1	4.91	1
Total Kjeldahl Nitrogen (ppm)	32000	107000	42400
% Solids	30	0.07	33.9
% Water	A.P.	A.P.	41.6
Oil & Grease (%)	A.P.	A.P.	24.5
BTU Content (BTU/LB) as received basis	9990	11732	9442
Total Sulphur (weight %)	8.41	0.01	9.23
Specific Gravity	1.22	1.12	1.2
pH	11.2	12.1	9.34
Electrical Conductance (umhos/cm)	6560	8880	16520
Particle size % Sand	I.S.	I.S.	I.S.
Particle size % Silt	I.S.	I.S.	I.S.
Particle size % Clay	I.S.	I.S.	I.S.
Free Liquid (%)	58	100	0
Flashpoint (Centigrade)	N/A	N/A	N/A
Flammability	no	no	no
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	20	40	40
Magnesium (ppm)	2.4	2.4	2.4
Sodium (ppm)	1686	9900	2780
Potassium (ppm)	547	556	28.9
Chloride (ppm)	28	1362	462
Sulphate (ppm)	190	1204	88
Bicarbonate (ppm)	0	0	0
Nitrate as N (ppm)	1	1	1
Sulfide (ppm)	45000	3800	30500
Leachate Analysis			
Arsenic (mg/L)	0.026	N/A	0.002
Barium (mg/L)	1.29	N/A	0.16
Boron (mg/L)	5.13	N/A	1.26
Cadmium (mg/L)	<0.001	N/A	<0.001
Chromium (mg/L)	0.014	N/A	0.011
Lead (mg/L)	0.02	N/A	<0.01
Mercury (ug/L)	0.19	N/A	<0.01
Selenium (mg/L)	<0.0002	N/A	<0.0002
Cyanide (mg/L)	0.078	N/A	0.04
Nitrate/Nitrite as N (mg/L)	0.05	N/A	0.5

(C:\LOTUS\B21\B4P-AMSH.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B4 – DEA AMINE SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA				
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5
Biological Oxygen Demand (ppm)					
Total Organic Carbon (weight %)			19.4		
Total Phosphorous (ppm)					
Total Kjeldahl Nitrogen (ppm)			4400		
% Solids				1.9	2.05
% Water	37.48		31.8		
Oil & Grease (%)	0.19		17.2		
BTU Content (BTU/LB) as received basis					
Total Sulphur (weight %)			4.32		
Specific Gravity					
pH		11.9	8.8		7.27
Electrical Conductance (umhos/cm)			15700		11800
Particle size % Sand					
Particle size % Silt					
Particle size % Clay					
Free Liquid (%)					
Flashpoint (Centigrade)					
Flammability					
Soluble Ions (On Total Sample Basis)					
Calcium (ppm)					
Magnesium (ppm)					
Sodium (ppm)					
Potassium (ppm)					
Chloride (ppm)					
Sulphate (ppm)				40240	3450
Bicarbonate (ppm)					
Nitrate as N (ppm)					
Sulfide (ppm)	2300				
Leachate Analysis					
Arsenic (mg/L)					
Barium (mg/L)					
Boron (mg/L)					
Cadmium (mg/L)					
Chromium (mg/L)					
Lead (mg/L)					
Mercury (ug/L)					
Selenium (mg/L)					
Cyanide (mg/L)					
Nitrate/Nitrite as N (mg/L)					

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B4 – DEA AMINE SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	204.53	0.6	485	205.03
Total Organic Carbon (weight %)	30.40	19.4	52.3	12.86
Total Phosphorous (ppm)	2.30	1	4.91	1.84
Total Kjeldahl Nitrogen (ppm)	45350.00	0	107000	38872.45
% Solids	13.58	0.07	33.9	15.06
% Water	22.18	0	41.6	18.37
Oil & Grease (%)	4.90	0	24.5	9.80
BTU Content (BTU/LB) as received basis	10388.00	9442	11732	976.33
Total Sulphur (weight %)	5.49	0.01	9.23	3.67
Specific Gravity	1.18	1.12	1.22	0.04
pH	10.10	7.27	12.1	1.77
Electrical Conductance (umhos/cm)	11892.00	6560	16520	3832.23
Particle size % Sand	N/A	N/A	N/A	N/A
Particle size % Silt	N/A	N/A	N/A	N/A
Particle size % Clay	N/A	N/A	N/A	N/A
Free Liquid (%)	52.67	0	100	41.00
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	33.33	20	40	9.43
Magnesium (ppm)	1.80	0	2.4	1.04
Sodium (ppm)	4788.67	1686	9900	3641.75
Potassium (ppm)	377.30	28.9	556	246.38
Chloride (ppm)	617.33	28	1362	555.57
Sulphate (ppm)	9034.40	88	40240	15649.61
Bicarbonate (ppm)	0.00	0	0	0.00
Nitrate as N (ppm)	1.00	1	1	0.00
Sulfide (ppm)	20400.00	2300	45000	18099.31
Leachate Analysis				
Arsenic (mg/L)	0.0140	0.002	0.026	0.0120
Barium (mg/L)	0.7250	0.16	1.29	0.5650
Boron (mg/L)	3.1950	1.26	5.13	1.9350
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	0.0125	0.011	0.014	0.0015
Lead (mg/L)	N/A	N/A	N/A	N/A
Mercury (ug/L)	N/A	N/A	N/A	N/A
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	0.0590	0.04	0.078	0.0190
Nitrate/Nitrite as N (mg/L)	0.2750	0.05	0.5	0.2250

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B5 – MEA AMINE SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	10500	4030	10900
Total Organic Carbon (weight %)	N.T.	N.T.	N.T.
Total Phosphorous (ppm)	<0.5	1.28	43
Total Kjeldahl Nitrogen (ppm)	14800	27000	34600
% Solids	61	0.008	66.1
% Water	33.5	A.P	30.8
Oil & Grease (ppm)	9900	0.6	6020
BTU Content (BTU/LB) as recieved basis	435	518	4700
Total Sulphur (weight %)	13.9	0.16	0.8
Specific Gravity	0.97	1.04	1.24
pH	10.6	9.9	9.9
Electrical Conductance (umhos/cm)	1900	13900	10700
Particle size % Sand	48	I.S	91
Particle size % Silt	40	I.S	5
Particle size % Clay	12	I.S	4
Free Liquid (%)	0	98	0
Flashpoint (Centigrade)	N/A	>128	N/A
Flammability	No	N.A	No
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	26	35	28
Magnesium (ppm)	3.2	14	8
Sodium (ppm)	550	5690	6670
Potassium (ppm)	4.3	468	45
Chloride (ppm)	58	1456	224
Sulphate (ppm)	102	1384	86
Bicarbonate (ppm)	41	84	26
Nitrate as N (ppm)	0.5	1	1
Sulfide (ppm)	456	6560	7140
Leachate Analysis			
Arsenic (mg/L)	0.006	0.003	0.0052
Barium (mg/L)	0.84	6.13	0.02
Boron (mg/L)	2.3	0.07	0.3
Cadmium (mg/L)	<0.001	<0.001	<0.001
Chromium (mg/L)	<0.001	<0.001	0.85
Lead (mg/L)	<0.01	<0.01	<0/01
Mercury (ug/L)	0.08	0.1	0.1
Selenium (mg/L)	<0.0002	<0.0002	0.002
Cyanide (mg/L)	<0.002	<0.002	0.035
Nitrate/Nitrite as N (mg/L)	0.03	0.01	0.05

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B5 – MEA AMINE SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Biological Oxygen Demand (ppm)				
Total Organic Carbon (weight %)	9.8	13.2	14.3	7.9
Total Phosphorous (ppm)				
Total Kjeldahl Nitrogen (ppm)	5000	5000	5000	2300
% Solids	9.2	22.2	35.5	43.6
% Water	60.8	58.8	59.5	52.5
Oil & Grease (ppm)	30	19	35	3.9
BTU Content (BTU/LB) as recieved basis				
Total Sulphur (weight %)	0.21	0.21	0.2	0.397
Specific Gravity				
pH	10.5	10.6	10.7	8
Electrical Conductance (umhos/cm)	5800	6400	5500	11500
Particle size % Sand				
Particle size % Silt				
Particle size % Clay				
Free Liquid (%)				
Flashpoint (Centigrade)				
Flammability				
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)				
Magnesium (ppm)				
Sodium (ppm)				
Potassium (ppm)				
Chloride (ppm)				
Sulphate (ppm)				
Bicarbonate (ppm)				
Nitrate as N (ppm)	160	190	130	
Sulfide (ppm)				
Leachate Analysis				
Arsenic (mg/L)				
Barium (mg/L)				
Boron (mg/L)				
Cadmium (mg/L)				
Chromium (mg/L)				
Lead (mg/L)				
Mercury (ug/L)				
Selenium (mg/L)				
Cyanide (mg/L)				
Nitrate/Nitrite as N (mg/L)				

(C:\LOTUS\2213GP-AP86.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B5 – MEA AMINE SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA		
	SAMPLE #5	SAMPLE #6	SAMPLE #7
Biological Oxygen Demand (ppm)			
Total Organic Carbon (weight %)		1.79	
Total Phosphorous (ppm)			
Total Kjeldahl Nitrogen (ppm)	4943	56000	89500
% Solids			
% Water			
Oil & Grease (ppm)	42.9	0.042	
BTU Content (BTU/LB) as recieved basis			
Total Sulphur (weight %)			
Specific Gravity			
pH	5.44	12.6	12.2
Electrical Conductance (umhos/cm)		13300	13400
Particle size % Sand			
Particle size % Silt			
Particle size % Clay			
Free Liquid (%)			
Flashpoint (Centigrade)			
Flammability			
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)			
Magnesium (ppm)			
Sodium (ppm)			
Potassium (ppm)			
Chloride (ppm)			
Sulphate (ppm)			
Bicarbonate (ppm)		490	
Nitrate as N (ppm)	0.46	0.4	0.01
Sulfide (ppm)			6640
Leachate Analysis			
Arsenic (mg/L)			
Barium (mg/L)			
Boron (mg/L)			
Cadmium (mg/L)			
Chromium (mg/L)			
Lead (mg/L)			
Mercury (ug/L)			
Selenium (mg/L)			
Cyanide (mg/L)			
Nitrate/Nitrite as N (mg/L)			

(C:\LOTUS\2213&P-AP&S.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B5 – MEA AMINE SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	8476.67	4030	10900	3148.51
Total Organic Carbon (weight %)	9.40	1.79	14.3	4.44
Total Phosphorous (ppm)	22.14	1.28	43	20.86
Total Kjeldahl Nitrogen (ppm)	24414.30	2300	89500	27268.28
% Solids	33.94	0.008	66.1	23.19
% Water	49.32	30.8	60.8	12.44
Oil & Grease (ppm)	1783.49	0.042	9900	3425.83
BTU Content (BTU/LB) as recieved basis	1884.33	435	4700	1991.27
Total Sulphur (weight %)	2.27	0.16	13.9	4.75
Specific Gravity	1.08	0.97	1.24	0.11
pH	10.04	5.44	12.6	1.95
Electrical Conductance (umhos/cm)	9155.56	1900	13900	4088.50
Particle size % Sand	69.50	48	91	21.50
Particle size % Silt	22.50	5	40	17.50
Particle size % Clay	8.00	4	12	4.00
Free Liquid (%)	32.67	0	98	46.20
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	29.67	26	35	3.86
Magnesium (ppm)	8.40	3.2	14	4.42
Sodium (ppm)	4303.33	550	6670	2683.99
Potassium (ppm)	172.43	4.3	468	209.66
Chloride (ppm)	579.33	58	1456	623.59
Sulphate (ppm)	524.00	86	1384	608.15
Bicarbonate (ppm)	160.25	26	490	191.57
Nitrate as N (ppm)	53.71	0.01	190	76.48
Sulfide (ppm)	5199.00	456	7140	2747.38
Leachate Analysis				
Arsenic (mg/L)	0.0047	0.003	0.006	0.0013
Barium (mg/L)	2.3300	0.02	6.13	2.7078
Boron (mg/L)	0.8900	0.07	2.3	1.0014
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	N/A	N/A	N/A	N/A
Lead (mg/L)	N/A	N/A	N/A	N/A
Mercury (ug/L)	0.0933	0.08	0.1	0.0094
Selenium (mg/L)	N/A	N/A	N/A	NA
Cyanide (mg/L)	N/A	N/A	N/A	NA
Nitrate/Nitrite as N (mg/L)	0.0300	0.01	0.05	0.0163

(C:\LOTUS\2215\GP-APB05.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. – Not Tested

TABLE B6 – DIGESTOR SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	2160		
Total Organic Carbon (weight %)	9.5		
Total Phosphorous (ppm)	34		
Total Kjeldahl Nitrogen (ppm)	1520		
Total Suspended Solids (ppm)	17050		
Volatile Suspended Solids (ppm)	13590		
% Solids	N.T.		
% Water	N.T.		
Oil & Grease (%)	N.T.		
BTU Content (BTU/LB) as recieved basis	3825		
Total Sulphur (weight %)	0.05		
Specific Gravity	0.99		
pH	7.64		
Electrical Conductance (umhos/cm)	2040		
Particle size % Sand	I.S.		
Particle size % Silt	I.S.		
Particle size % Clay	I.S.		
Free Liquid (%)	60		
Flashpoint (Centigrade)	N/A		
Flammability	no		
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	64		
Magnesium (ppm)	9.8		
Sodium (ppm)	288		
Potassium (ppm)	43.8		
Chloride (ppm)	46		
Sulphate (ppm)	386		
Bicarbonate (ppm)	802		
Nitrate as N (ppm)	1		
Sulfide (ppm)	120		
Leachate Analysis			
Arsenic (mg/L)	0.016		
Barium (mg/L)	0.33		
Boron (mg/L)	0.06		
Cadmium (mg/L)	<0.001		
Chromium (mg/L)	<0.001		
Lead (mg/L)	<0.01		
Mercury (ug/L)	0.12		
Selenium (mg/L)	<0.0002		
Cyanide (mg/L)	<0.002		
Nitrate/Nitrite as N (mg/L)	0.05		

(C:\LOTUS\2213\GP-APB06.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B6 – DIGESTOR SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Biological Oxygen Demand (ppm)				
Total Organic Carbon (weight %)	0.45	0.338		
Total Phosphorous (ppm)				
Total Kjeldahl Nitrogen (ppm)				
Total Suspended Solids (ppm)	15000	26600	30350	
Volatile Suspended Solids (ppm)				
% Solids				
% Water		89.4	97.3	
Oil & Grease (%)	0.14	0.33	0.14	
BTU Content (BTU/LB) as recieved basis				
Total Sulphur (weight %)				
Specific Gravity				
pH	8.37	8.39	7.98	7.8
Electrical Conductance (umhos/cm)		5968	4750	
Particle size % Sand				
Particle size % Silt				
Particle size % Clay				
Free Liquid (%)				
Flashpoint (Centigrade)				
Flammability				

Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	48.7	60	193	
Magnesium (ppm)	117	212	293	
Sodium (ppm)	458	512	710	2270
Potassium (ppm)	51.3	62.78		1240
Chloride (ppm)	903	878		7460
Sulphate (ppm)	373	246	410	216
Bicarbonate (ppm)				
Nitrate as N (ppm)				
Sulfide (ppm)				

Leachate Analysis				
Arsenic (mg/L)				
Barium (mg/L)				
Boron (mg/L)				
Cadmium (mg/L)				
Chromium (mg/L)				
Lead (mg/L)				
Mercury (ug/L)				
Selenium (mg/L)				
Cyanide (mg/L)				
Nitrate/Nitrite as N (mg/L)				

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B6 – DIGESTOR SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	2160.00	2160	2160	0.00
Total Organic Carbon (weight %)	3.43	0.338	9.5	4.29
Total Phosphorous (ppm)	34.00	34	34	0.00
Total Kjeldahl Nitrogen (ppm)	1520.00	1520	1520	0.00
Total Suspended Solids (ppm)	22250.00	15000	30350	6405.76
Volatile Suspended Solids (ppm)	13590.00	13590	13590	0.00
% Solids	N/A	N/A	N/A	N/A
% Water	93.35	89.4	97.3	3.95
Oil & Grease (%)	0.20	0.14	0.33	0.09
BTU Content (BTU/LB) as recieved basis	3825.00	3825	3825	0.00
Total Sulphur (weight %)	0.05	0.05	0.05	0.00
Specific Gravity	0.99	0.99	0.99	ERR
pH	8.04	7.64	8.39	0.30
Electrical Conductance (umhos/cm)	4252.67	2040	5968	1641.71
Particle size % Sand	N/A	N/A	N/A	N/A
Particle size % Silt	N/A	N/A	N/A	N/A
Particle size % Clay	N/A	N/A	N/A	N/A
Free Liquid (%)	60.00	60	60	0.00
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	91.425	48.7	193	58.91
Magnesium (ppm)	157.95	9.8	293	105.81
Sodium (ppm)	847.6	288	2270	723.84
Potassium (ppm)	349.47	43.8	1240	514.19
Chloride (ppm)	2321.75	46	7460	2986.55
Sulphate (ppm)	326.2	216	410	79.20
Bicarbonate (ppm)	802	802	802	0.00
Nitrate as N (ppm)	1	1	1	0.00
Sulfide (ppm)	120	120	120	0.00
Leachate Analysis				
Arsenic (mg/L)	0.016	0.016	0.016	0.0000
Barium (mg/L)	0.33	0.33	0.33	0.0000
Boron (mg/L)	0.06	0.06	0.06	0.0000
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	N/A	N/A	N/A	N/A
Lead (mg/L)	N/A	N/A	N/A	N/A
Mercury (ug/L)	0.12	0.12	0.12	0.0000
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	N/A	N/A	N/A	N/A
Nitrate/Nitrite as N (mg/L)	0.05	0.05	0.05	0.0000

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B7 - FILTER BACKWASH POND SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	237	1462	13600
Total Organic Carbon (weight %)	10.2	3.3	8
Total Phosphorous (ppm)	3.9	595	226
Total Kjeldahl Nitrogen (ppm)	789	1140	1700
% Solids	20.6	81	37.6
% Water	73.8	16.3	57
Oil & Grease (ppm)	56000	9120	2150
BTU Content (BTU/LB) as recieved basis	18445	792	217
Total Sulphur (weight %)	0.75	0.59	1.75
Specific Gravity	0.86	1.14	1.25
pH	6.9	6.49	8.05
Electrical Conductance (umhos/cm)	840	5100	5000
Particle size % Sand	I.S.	44	10
Particle size % Silt	I.S.	32	80
Particle size % Clay	I.S.	24	10
Free Liquid (%)	8	0	0
Flashpoint (Centigrade)	16	N/A	N/A
Flammability	yes	no	no
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	64	560	80
Magnesium (ppm)	4.9	98	49
Sodium (ppm)	59.6	156	96.2
Potassium (ppm)	4.7	142	7.82
Chloride (ppm)	74	152	10.2
Sulphate (ppm)	82.6	2520	7
Bicarbonate (ppm)	204	0	3050
Nitrate as N (ppm)	1	0.318	0.02
Sulfide (ppm)	120	56	3590
Leachate Analysis			
Arsenic (mg/L)	N/A	0.0012	0.0018
Barium (mg/L)	N/A	0.18	0.1
Boron (mg/L)	N/A	0.2	0.13
Cadmium (mg/L)	N/A	<0.001	<0.001
Chromium (mg/L)	N/A	0.002	0.005
Lead (mg/L)	N/A	<0.01	0.04
Mercury (ug/L)	N/A	0.1	0.1
Selenium (mg/L)	N/A	<0.0002	<0.0002
Cyanide (mg/L)	N/A	0.003	0.001
Nitrate/Nitrite as N (mg/L)	N/A	0.016	0.001

(C:\LOTUS\2213\BP-APB07.WK1)

A.P. - Analytical Problems / I.S. - Insufficient Sample / N/A - Not Applicable / N.T. Not Tested

TABLE B7 – FILTER BACKWASH POND SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	5099.67	237	13600	5223.36
Total Organic Carbon (weight %)	7.17	3.3	10.2	2.49
Total Phosphorous (ppm)	274.97	3.9	595	211.13
Total Kjeldahl Nitrogen (ppm)	1209.67	789	1700	324.90
% Solids	46.40	20.6	81	22.02
% Water	49.03	16.3	73.8	20.91
Oil & Grease (ppm)	22423.33	2150	56000	20708.57
BTU Content (BTU/LB) as recieved basis	6484.67	217	18445	7327.00
Total Sulphur (weight %)	1.03	0.59	1.75	0.44
Specific Gravity	1.08	0.86	1.25	0.14
pH	7.15	6.49	8.05	0.57
Electrical Conductance (umhos/cm)	3646.67	840	5100	1719.09
Particle size % Sand	18.00	0	44	16.31
Particle size % Silt	37.33	0	80	28.47
Particle size % Clay	11.33	0	24	8.52
Free Liquid (%)	2.67	0	8	3.27
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	234.67	64	560	199.31
Magnesium (ppm)	50.63	4.9	98	32.93
Sodium (ppm)	103.93	59.6	156	34.41
Potassium (ppm)	51.51	4.7	142	55.43
Chloride (ppm)	78.73	10.2	152	50.22
Sulphate (ppm)	869.87	7	2520	1010.85
Bicarbonate (ppm)	1084.67	0	3050	1205.68
Nitrate as N (ppm)	0.45	0.02	1	0.36
Sulfide (ppm)	1255.33	56	3590	1429.86
Leachate Analysis				
Arsenic (mg/L)	0.0015	0.0012	0.0018	0.0003
Barium (mg/L)	0.1400	0.1	0.18	0.0400
Boron (mg/L)	0.1650	0.13	0.2	0.0350
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	0.0035	0.002	0.005	0.0015
Lead (mg/L)	N/A	N/A	N/A	N/A
Mercury (ug/L)	0.1000	0.1	0.1	0.0000
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	0.0020	0.001	0.003	0.0010
Nitrate/Nitrite as N (mg/L)	0.0085	0.001	0.016	0.0075

(C:\LOTUS\2213\GP-APB07.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B8 – FLARE PIT SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	9860	1095	1250
Total Organic Carbon (weight %)	5.1	17.5	0.48
Total Phosphorous (ppm)	338	315	380
Total Kjeldahl Nitrogen (ppm)	2470	792	250
% Solids	64.4	73.6	86.6
% Water	30.7	9.06	13.1
Oil & Grease (ppm)	49000	263000	1967
BTU Content (BTU/LB) as recieved basis	1126	4067	610
Total Sulphur (weight %)	0.83	3.57	0.01
Specific Gravity	1.53	1.72	1.2
pH	8.51	7.76	8.8
Electrical Conductance (umhos/cm)	20800	600	5100
Particle size % Sand	82	42	62
Particle size % Silt	14	39	32
Particle size % Clay	14	19	6
Free Liquid (%)	8	2.4	0
Flashpoint (Centigrade)	N/A	N/A	N/A
Flammability	no	no	no
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	180	60	720
Magnesium (ppm)	48.8	12	305
Sodium (ppm)	3580	64.1	119
Potassium (ppm)	310	8.6	45.4
Chloride (ppm)	6000	8	24
Sulphate (ppm)	1520	37.5	3120
Bicarbonate (ppm)	0	95.2	115
Nitrate as N (ppm)	10	0.68	1.26
Sulfide (ppm)	240	2.8	64
Leachate Analysis			
Arsenic (mg/L)	0.002	0.0036	0.0017
Barium (mg/L)	0.42	18.6	0.22
Boron (mg/L)	0.14	0.07	0.2
Cadmium (mg/L)	<0.001	0.004	<0.001
Chromium (mg/L)	<0.001	<0.001	0.002
Lead (mg/L)	<0.01	<0.01	<0.01
Mercury (ug/L)	0.05	0.1	0.026
Selenium (mg/L)	0.002	<0.0002	0.001
Cyanide (mg/L)	0.014	<0.002	<0.002
Nitrate/Nitrite as N (mg/L)	0.5	0.03	0.063

(C:\LOTUS\2213\SP-AP508.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B8 – FLARE PIT SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Biological Oxygen Demand (ppm)				
Total Organic Carbon (weight %)				
Total Phosphorous (ppm)				
Total Kjeldahl Nitrogen (ppm)				675
% Solids	26.1			14.5
% Water				
Oil & Grease (ppm)				
BTU Content (BTU/LB) as recieved basis				
Total Sulphur (weight %)		1.48		
Specific Gravity				
pH	9.4	7.6		7.6
Electrical Conductance (umhos/cm)				
Particle size % Sand				
Particle size % Silt				
Particle size % Clay				
Free Liquid (%)				
Flashpoint (Centigrade)				
Flammability				
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)		16000		
Magnesium (ppm)		6000		
Sodium (ppm)		1550		
Potassium (ppm)		1300		
Chloride (ppm)		3950	370	
Sulphate (ppm)		360	0.2	
Bicarbonate (ppm)				
Nitrate as N (ppm)				
Sulfide (ppm)				14000
Leachate Analysis				
Arsenic (mg/L)				
Barium (mg/L)				
Boron (mg/L)				
Cadmium (mg/L)				
Chromium (mg/L)				
Lead (mg/L)				
Mercury (ug/L)				
Selenium (mg/L)				
Cyanide (mg/L)				
Nitrate/Nitrite as N (mg/L)				

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B8 – FLARE PIT SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	4068.33	1095	9860	4095.82
Total Organic Carbon (weight %)	7.69	0.48	17.5	7.19
Total Phosphorous (ppm)	344.33	315	380	26.91
Total Kjeldahl Nitrogen (ppm)	1046.75	250	2470	846.10
% Solids	53.04	14.5	86.6	27.89
% Water	17.62	9.06	30.7	9.39
Oil & Grease (ppm)	104655.67	1967	263000	113600.83
BTU Content (BTU/LB) as recieved basis	1934.33	610	4067	1522.67
Total Sulphur (weight %)	1.47	0.01	3.57	1.32
Specific Gravity	1.48	1.2	1.72	0.21
pH	8.28	7.6	9.4	0.68
Electrical Conductance (umhos/cm)	8833.33	600	20800	8658.84
Particle size % Sand	62.00	42	82	16.33
Particle size % Silt	28.33	14	39	10.53
Particle size % Clay	13.00	6	19	5.35
Free Liquid (%)	3.47	0	8	3.35
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	4240.00	60	16000	6794.19
Magnesium (ppm)	1591.45	12	6000	2547.78
Sodium (ppm)	1328.28	64.1	3580	1430.03
Potassium (ppm)	416.00	8.6	1300	523.45
Chloride (ppm)	2070.40	8	6000	2462.00
Sulphate (ppm)	1007.54	0.2	3120	1191.65
Bicarbonate (ppm)	70.07	0	115	50.20
Nitrate as N (ppm)	3.98	0.68	10	4.26
Sulfide (ppm)	3576.70	2.8	14000	6018.52
Leachate Analysis				
Arsenic (mg/L)	0.0024	0.0017	0.0036	0.0008
Barium (mg/L)	6.4133	0.22	18.6	8.6177
Boron (mg/L)	0.1367	0.07	0.2	0.0531
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	N/A	N/A	N/A	N/A
Lead (mg/L)	N/A	N/A	N/A	N/A
Mercury (ug/L)	0.0587	0.026	0.1	0.0308
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	N/A	N/A	N/A	N/A
Nitrate/Nitrite as N (mg/L)	0.1977	0.03	0.5	0.2142

(C:\LOTUS\2213\GP-AP808.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B9 – GLYCOL SYSTEM SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	1470	5790	294
Total Organic Carbon (weight %)	25.7	50.2	32.7
Total Phosphorous (ppm)	8.4	18.9	8.8
Total Kjeldahl Nitrogen (ppm)	595	842	58
% Solids	5.34	3.73	A.P.
% Water	A.P.	A.P.	A.P.
Oil & Grease (%)	A.P.	A.P.	A.P.
BTU Content (BTU/LB) as recieved basis	4217	4983	3117
Total Sulphur (weight %)	2.35	1.18	0.01
Specific Gravity	1.14	1.12	1.08
pH	8.72	8.91	7.43
Electrical Conductance (umhos/cm)	1280	1040	100
Particle size % Sand	I.S.	I.S.	I.S.
Particle size % Silt	I.S.	I.S.	I.S.
Particle size % Clay	I.S.	I.S.	I.S.
Free Liquid (%)	60	64	100
Flashpoint (Centigrade)	48	40	100
Flammability	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	16	32	8
Magnesium (ppm)	4.9	4.9	4.9
Sodium (ppm)	724	554	13.7
Potassium (ppm)	25.8	10.9	3.13
Chloride (ppm)	306	212	9.2
Sulphate (ppm)	25	108	2.4
Bicarbonate (ppm)	0	0	110
Nitrate as N (ppm)	1	1	0.94
Sulfide (ppm)	1280	2600	56
Leachate Analysis			
Arsenic (mg/L)	N.T.	N.T.	0.0029
Barium (mg/L)	N.T.	N.T.	0.02
Boron (mg/L)	N.T.	N.T.	1.09
Cadmium (mg/L)	N.T.	N.T.	<0.001
Chromium (mg/L)	N.T.	N.T.	0.003
Lead (mg/L)	N.T.	N.T.	0.02
Mercury (ug/L)	N.T.	N.T.	0.1
Selenium (mg/L)	N.T.	N.T.	<0.0002
Cyanide (mg/L)	N.T.	N.T.	0.003
Nitrate/Nitrite as N (mg/L)	N.T.	N.T.	0.047

(C:\LOTUS\2213\GP-APB09.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B9 – GLYCOL SYSTEM SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Biological Oxygen Demand (ppm)				
Total Organic Carbon (weight %)				
Total Phosphorous (ppm)				
Total Kjeldahl Nitrogen (ppm)				
% Solids	12.6	4.8	10.8	10.5
% Water	0.5	2.5	0.9	2.5
Oil & Grease (%)				
BTU Content (BTU/LB) as recieved basis				
Total Sulphur (weight %)				
Specific Gravity				
pH		5.3	3.8	7.05
Electrical Conductance (umhos/cm)				
Particle size % Sand				
Particle size % Silt				
Particle size % Clay				
Free Liquid (%)				
Flashpoint (Centigrade)				
Flammability				
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)				
Magnesium (ppm)				
Sodium (ppm)				
Potassium (ppm)				
Chloride (ppm)				
Sulphate (ppm)				
Bicarbonate (ppm)				
Nitrate as N (ppm)				
Sulfide (ppm)		3100		
Leachate Analysis				
Arsenic (mg/L)				
Barium (mg/L)				
Boron (mg/L)				
Cadmium (mg/L)				
Chromium (mg/L)				
Lead (mg/L)				
Mercury (ug/L)				
Selenium (mg/L)				
Cyanide (mg/L)				
Nitrate/Nitrite as N (mg/L)				

(C:\LOTUS\2213\GP-APB08.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B9 – GLYCOL SYSTEM SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	2518.00	294	5790	2362.94
Total Organic Carbon (weight %)	36.20	25.7	50.2	10.30
Total Phosphorous (ppm)	12.03	8.4	18.9	4.86
Total Kjeldahl Nitrogen (ppm)	498.33	58	842	327.28
% Solids	7.96	3.73	12.6	4.23
% Water	1.60	0.5	2.5	1.05
Oil & Grease (%)	N/A	N/A	N/A	N/A
BTU Content (BTU/LB) as recieved basis	4105.67	3117	4983	765.85
Total Sulphur (weight %)	1.18	0.01	2.35	0.96
Specific Gravity	1.11	1.08	1.14	0.02
pH	6.87	3.8	8.91	1.82
Electrical Conductance (umhos/cm)	806.67	100	1280	509.20
Particle size % Sand	N/A	N/A	N/A	N/A
Particle size % Silt	N/A	N/A	N/A	N/A
Particle size % Clay	N/A	N/A	N/A	N/A
Free Liquid (%)	74.67	60	100	17.99
Flashpoint (Centigrade)	62.67	40	100	26.60
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	18.67	8	32	9.98
Magnesium (ppm)	4.90	4.9	4.9	0.00
Sodium (ppm)	430.57	13.7	724	302.83
Potassium (ppm)	13.28	3.13	25.8	9.41
Chloride (ppm)	175.73	9.2	306	123.85
Sulphate (ppm)	45.13	2.4	108	45.40
Bicarbonate (ppm)	36.67	0	110	51.85
Nitrate as N (ppm)	0.98	0.94	1	0.03
Sulfide (ppm)	1759.00	56	3100	1186.93
Leachate Analysis				
Arsenic (mg/L)	N/A	N/A	N/A	N/A
Barium (mg/L)	N/A	N/A	N/A	N/A
Boron (mg/L)	N/A	N/A	N/A	N/A
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	N/A	N/A	N/A	N/A
Lead (mg/L)	N/A	N/A	N/A	N/A
Mercury (ug/L)	N/A	N/A	N/A	N/A
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	N/A	N/A	N/A	N/A
Nitrate/Nitrite as N (mg/L)	N/A	N/A	N/A	N/A

(C:\LOTUS\2213\GP-APB39.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B10 – INLET SEPARATOR SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	375	4390	8130
Total Organic Carbon (weight %)	5.9	3.6	7.2
Total Phosphorous (ppm)	82	2.08	0.5
Total Kjeldahl Nitrogen (ppm)	442	142	1290
% Solids	70.7	1.57	76.2
% Water	22.1	A.P.	A.P.
Oil & Grease (%)	0.41	0.0845	1.09
BTU Content (BTU/LB) as received basis	1159	N.T.	1470
Total Sulphur (weight %)	0.99	0.11	23.5
Specific Gravity	1.9	1	1.25
pH	6.64	8.2	9.2
Electrical Conductance (umhos/cm)	10600	870	910
Particle size % Sand	45	I.S.	78
Particle size % Silt	30	I.S.	10
Particle size % Clay	25	I.S.	12
Free Liquid (%)	0	100	0
Flashpoint (Centigrade)	N/A	>128	N/A
Flammability	no	N/A	yes
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	240	120	58
Magnesium (ppm)	49	12	24
Sodium (ppm)	1900	112	251
Potassium (ppm)	14.9	11	3.8
Chloride (ppm)	2940	357	217
Sulphate (ppm)	3.6	38	52.1
Bicarbonate (ppm)	615	162	78
Nitrate as N (ppm)	2.24	1.6	4.7
Sulfide (ppm)	400	20	320
Leachate Analysis			
Arsenic (mg/L)	0.001	0.007	N/A
Barium (mg/L)	1.64	0.34	N/A
Boron (mg/L)	0.41	0.56	N/A
Cadmium (mg/L)	<0.001	<0.001	N/A
Chromium (mg/L)	0.002	<0.001	N/A
Lead (mg/L)	0.02	<0.01	N/A
Mercury (ug/L)	0.1	0.07	N/A
Selenium (mg/L)	<0.0002	<0.0002	N/A
Cyanide (mg/L)	<0.002	<0.002	N/A
Nitrate/Nitrite as N (mg/L)	0.112	<0.01	N/A

(C:\LOTUS\2213\SP-APB10.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B10 – INLET SEPARATOR SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)			
Total Organic Carbon (weight %)			
Total Phosphorous (ppm)			
Total Kjeldahl Nitrogen (ppm)			
% Solids	0.95	1.2	88.8
% Water	97.7	26.6	2.9
Oil & Grease (%)	2.3	72.7	8.3
BTU Content (BTU/LB) as received basis			
Total Sulphur (weight %)	15.3		30
Specific Gravity			
pH	7.75		
Electrical Conductance (umhos/cm)			
Particle size % Sand			
Particle size % Silt			
Particle size % Clay			
Free Liquid (%)			
Flashpoint (Centigrade)			
Flammability			
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	710		
Magnesium (ppm)	130		
Sodium (ppm)	2300		
Potassium (ppm)			
Chloride (ppm)			
Sulphate (ppm)			
Bicarbonate (ppm)			
Nitrate as N (ppm)			
Sulfide (ppm)	105000		
Leachate Analysis			
Arsenic (mg/L)			
Barium (mg/L)			
Boron (mg/L)			
Cadmium (mg/L)			
Chromium (mg/L)			
Lead (mg/L)			
Mercury (ug/L)			
Selenium (mg/L)			
Cyanide (mg/L)			
Nitrate/Nitrite as N (mg/L)			

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B10 – INLET SEPARATOR SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	4298.33	375	8130	3166.63
Total Organic Carbon (weight %)	5.57	3.6	7.2	1.49
Total Phosphorous (ppm)	28.19	0.5	82	38.05
Total Kjeldahl Nitrogen (ppm)	624.67	142	1290	486.14
% Solids	39.90	0.95	88.8	39.03
% Water	37.33	2.9	97.7	35.98
Oil & Grease (%)	14.15	0.0845	72.7	26.33
BTU Content (BTU/LB) as received basis	1314.50	1159	1470	155.50
Total Sulphur (weight %)	13.98	0.11	30	11.92
Specific Gravity	1.38	1	1.9	0.38
pH	7.95	6.64	9.2	0.92
Electrical Conductance (umhos/cm)	4126.67	870	10600	4577.37
Particle size % Sand	61.50	45	78	16.50
Particle size % Silt	20.00	10	30	10.00
Particle size % Clay	18.50	12	25	6.50
Free Liquid (%)	33.33	0	100	47.14
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	282.00	58	710	255.62
Magnesium (ppm)	53.75	12	130	46.00
Sodium (ppm)	1140.75	112	2300	970.86
Potassium (ppm)	9.90	3.8	14.9	4.60
Chloride (ppm)	1171.33	217	2940	1251.94
Sulphate (ppm)	31.23	3.6	52.1	20.37
Bicarbonate (ppm)	285.00	78	615	235.85
Nitrate as N (ppm)	2.85	1.6	4.7	1.34
Sulfide (ppm)	26435.00	20	105000	45359.75
Leachate Analysis				
Arsenic (mg/L)	0.0040	0.001	0.007	0.0030
Barium (mg/L)	0.9900	0.34	1.64	0.6500
Boron (mg/L)	0.4850	0.41	0.56	0.0750
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	N/A	N/A	N/A	N/A
Lead (mg/L)	N/A	N/A	N/A	N/A
Mercury (ug/L)	0.0850	0.07	0.1	0.0150
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	N/A	N/A	N/A	N/A
Nitrate/Nitrite as N (mg/L)	N/A	N/A	N/A	N/A

(C:\LOTUS\3213\GP-AP810.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Sample / N/A – Not Applicable / N.T. Not Tested

TABLE B11 – LIME SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	375		
Total Organic Carbon (weight %)	5.9		
Total Phosphorous (ppm)	82		
Total Kjeldahl Nitrogen (ppm)	442		
Total Suspended Solids (ppm)			
Volatile Suspended Solids (ppm)			
% Solids	70.7		
% Water	22.1		
Oil Content (%)	4100		
BTU Content (BTU/LB) as recieved basis	1159		
Total Sulphur (weight %)	0.99		
Specific Gravity	1.9		
pH	6.64		
Electrical Conductance (umhos/cm)	10600		
Particle size % Sand	45		
Particle size % Silt	30		
Particle size % Clay	25		
Free Liquid (%)	0		
Flashpoint (Centigrade)			
Flammability	no		
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	240		
Magnesium (ppm)	49		
Sodium (ppm)	1900		
Potassium (ppm)	14.9		
Chloride (ppm)	2940		
Sulphate (ppm)	3.6		
Bicarbonate (ppm)	615		
Nitrate as N (ppm)	2.24		
Sulfide (ppm)	400		
Leachate Analysis			
Arsenic (mg/L)	0.001		
Barium (mg/L)	1.64		
Boron (mg/L)	0.41		
Cadmium (mg/L)	0.001		
Chromium (mg/L)	0.002		
Lead (mg/L)	0.02		
Mercury (ug/L)	0.1		
Selenium (mg/L)	0.0002		
Cyanide (mg/L)	0.001		
Nitrate/Nitrite as N (mg/L)	0.112		

A.P. – Analytical Problems/I.S. – Insufficient Samples/N/A – Not Applicable/N.T. – Not Tested

TABLE B11 – LIME SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)			
Total Organic Carbon (weight %)			
Total Phosphorous (ppm)			
Total Kjeldahl Nitrogen (ppm)			
Total Suspended Solids (ppm)			
Volatile Suspended Solids (ppm)			
% Solids	0.95	1.2	88.8
% Water		26.6	2.9
Oil Content (%)			
BTU Content (BTU/LB) as recieved basis			
Total Sulphur (weight %)	15.3		30
Specific Gravity			
pH	7.75		
Electrical Conductance (umhos/cm)			
Particle size % Sand			
Particle size % Silt			
Particle size % Clay			
Free Liquid (%)			
Flashpoint (Centigrade)			
Flammability			

Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	710		
Magnesium (ppm)	130		
Sodium (ppm)	2300		
Potassium (ppm)			
Chloride (ppm)			
Sulphate (ppm)			
Bicarbonate (ppm)			
Nitrate as N (ppm)			
Sulfide (ppm)	105000		

Leachate Analysis			
Arsenic (mg/L)			
Barium (mg/L)			
Boron (mg/L)			
Cadmium (mg/L)			
Chromium (mg/L)			
Lead (mg/L)			
Mercury (ug/L)			
Selenium (mg/L)			
Cyanide (mg/L)			
Nitrate/Nitrite as N (mg/L)			

A.P. – Analytical Problems/I.S. – Insufficient Samples/N/A – Not Applicable/N.T. – Not Tested

TABLE B11 – LIME SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	375.00	375	375	0.00
Total Organic Carbon (weight %)	2.95	0	5.9	2.95
Total Phosphorous (ppm)	82.00	82	82	0.00
Total Kjeldahl Nitrogen (ppm)	442.00	442	442	0.00
Total Suspended Solids (ppm)	0.00	0	0	0.00
Volatile Suspended Solids (ppm)	0.00	0	0	0.00
% Solids	40.41	0.95	88.8	39.85
% Water	12.90	0	26.6	11.61
Oil Content (%)	4100.00	4100	4100	0.00
BTU Content (BTU/LB) as recieved basis	1159.00	1159	1159	0.00
Total Sulphur (weight %)	15.43	0.99	30	11.84
Specific Gravity	1.90	1.9	1.9	0.00
pH	7.20	6.64	7.75	0.55
Electrical Conductance (umhos/cm)	10600.00	10600	10600	0.00
Particle size % Sand	45.00	45	45	0.00
Particle size % Silt	30.00	30	30	0.00
Particle size % Clay	25.00	25	25	0.00
Free Liquid (%)	0.00	0	0	0.00
Flashpoint (Centigrade)	0.00	0	0	0.00
Flammability	0.00	0	0	0.00
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	475.00	240	710	235.00
Magnesium (ppm)	89.50	49	130	40.50
Sodium (ppm)	2100.00	1900	2300	200.00
Potassium (ppm)	14.90	14.9	14.9	0.00
Chloride (ppm)	2940.00	2940	2940	0.00
Sulphate (ppm)	3.60	3.6	3.6	0.00
Bicarbonate (ppm)	615.00	615	615	0.00
Nitrate as N (ppm)	1.12	0	2.24	1.12
Sulfide (ppm)	52700.00	400	105000	52300.00
Leachate Analysis				
Arsenic (mg/L)	0.0005	0	0.001	0.0005
Barium (mg/L)	0.8200	0	1.64	0.8200
Boron (mg/L)	0.2050	0	0.41	0.2050
Cadmium (mg/L)	0.0005	0	0.001	0.0005
Chromium (mg/L)	0.0010	0	0.002	0.0010
Lead (mg/L)	0.0200	0.02	0.02	0.0000
Mercury (ug/L)	0.1000	0.1	0.1	0.0000
Selenium (mg/L)	0.0001	0	0.0002	0.0001
Cyanide (mg/L)	0.0005	0	0.001	0.0005
Nitrate/Nitrite as N (mg/L)	0.1120	0.112	0.112	0.0000

A.P. – Analytical Problems/I.S. – Insufficient Samples/N/A – Not Applicable/N.T. – Not Tested

TABLE B12 – NEUTRALIZED SULPHUR POND SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	N.T.	N.T.	N.T.
Total Organic Carbon (weight %)	N.T.	N.T.	N.T.
Total Phosphorous (ppm)	N.T.	N.T.	N.T.
Total Kjeldahl Nitrogen (ppm)	N.T.	N.T.	N.T.
% Solids	63	37	73.8
% Water	35.8	62.9	25.3
Oil & Grease (%)	1.2	0.006	0.007
BTU Content (BTU/LB) as recieved basis	1329	1251	23
Total Sulphur (weight %)	2.98	0.85	1.37
Specific Gravity	1.3	1.26	1.8
pH	7.24	7.41	7.26
Electrical Conductance (umhos/cm)	4740	4860	6040
Particle size % Sand	12	57	80
Particle size % Silt	75	35	18
Particle size % Clay	13	8	2
Free Liquid (%)	0	0	2
Flashpoint (Centigrade)	N/A	N/A	N/A
Flammability	no	no	N.T.
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	1080	340	1040
Magnesium (ppm)	830	110	244
Sodium (ppm)	211	742	77.9
Potassium (ppm)	64.1	45.5	28.2
Chloride (ppm)	202	15.6	132
Sulphate (ppm)	N.T.	N.T.	N.T.
Bicarbonate (ppm)	522	455	176
Nitrate as N (ppm)	N.T.	N.T.	N.T.
Sulfide (ppm)	10	960	N.T.
Leachate Analysis			
Arsenic (mg/L)	0.0003	0.004	0.0026
Barium (mg/L)	0.07	0.07	0.03
Boron (mg/L)	0.09	0.07	0.04
Cadmium (mg/L)	<0.001	<0.001	<0.001
Chromium (mg/L)	<0.001	<0.001	<0.001
Lead (mg/L)	0.03	<0.01	<0.01
Mercury (ug/L)	0.05	0.05	0.1
Selenium (mg/L)	<0.0002	<0.0002	<0.0002
Cyanide (mg/L)	0.006	<0.002	<0.002
Nitrate/Nitrite as N (mg/L)	0.07	0.01	0.017

(C:\LOTUS\2213\GP-APB12.WK1) SHEET 1 OF 3

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B12 – NEUTRALIZED SULPHUR POND SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA	
	SAMPLE #1	SAMPLE #2
Biological Oxygen Demand (ppm)		
Total Organic Carbon (weight %)		
Total Phosphorous (ppm)		
Total Kjeldahl Nitrogen (ppm)		
% Solids		
% Water		
Oil & Grease (%)		
BTU Content (BTU/LB) as recieved basis		
Total Sulphur (weight %)	5.81	4.19
Specific Gravity		
pH	9.2	7.7
Electrical Conductance (umhos/cm)		
Particle size % Sand		
Particle size % Silt		
Particle size % Clay		
Free Liquid (%)		
Flashpoint (Centigrade)		
Flammability		
Soluble Ions (On Total Sample Basis)		
Calcium (ppm)	164100	31300
Magnesium (ppm)	12400	6700
Sodium (ppm)	2270	
Potassium (ppm)	105	
Chloride (ppm)	50	10
Sulphate (ppm)	3500	3138
Bicarbonate (ppm)		
Nitrate as N (ppm)		
Sulfide (ppm)		
Leachate Analysis		
Arsenic (mg/L)		
Barium (mg/L)		
Boron (mg/L)		
Cadmium (mg/L)		
Chromium (mg/L)		
Lead (mg/L)		
Mercury (ug/L)		
Selenium (mg/L)		
Cyanide (mg/L)		
Nitrate/Nitrite as N (mg/L)		

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B12 – NEUTRALIZED SULPHUR POND SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	N/A	N/A	N/A	N/A
Total Organic Carbon (weight %)	N/A	N/A	N/A	N/A
Total Phosphorous (ppm)	N/A	N/A	N/A	N/A
Total Kjeldahl Nitrogen (ppm)	N/A	N/A	N/A	N/A
% Solids	57.93	37	73.8	15.44
% Water	41.33	25.3	62.9	15.84
Oil & Grease (%)	0.40	0.006	1.2	0.56
BTU Content (BTU/LB) as recieved basis	867.67	23	1329	598.12
Total Sulphur (weight %)	3.04	0.85	5.81	1.82
Specific Gravity	1.45	1.26	1.8	0.25
pH	7.76	7.24	9.2	0.74
Electrical Conductance (umhos/cm)	5213.33	4740	6040	586.59
Particle size % Sand	49.67	12	80	28.24
Particle size % Silt	42.67	18	75	23.89
Particle size % Clay	7.67	2	13	4.50
Free Liquid (%)	0.67	0	2	0.94
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	39572.00	340	164100	63373.73
Magnesium (ppm)	4056.80	110	12400	4839.88
Sodium (ppm)	825.23	77.9	2270	870.35
Potassium (ppm)	60.70	28.2	105	28.55
Chloride (ppm)	81.92	10	202	74.18
Sulphate (ppm)	3319.00	3138	3500	181.00
Bicarbonate (ppm)	384.33	176	522	149.83
Nitrate as N (ppm)	N/A	N/A	N/A	N/A
Sulfide (ppm)	485.00	10	960	475.00
Leachate Analysis				
Arsenic (mg/L)	0.0023	0.0003	0.004	0.00
Barium (mg/L)	0.0567	0.03	0.07	0.02
Boron (mg/L)	0.0667	0.04	0.09	0.02
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	N/A	N/A	N/A	N/A
Lead (mg/L)	N/A	N/A	N/A	N/A
Mercury (ug/L)	0.0667	0.05	0.1	0.02
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	N/A	N/A	N/A	N/A
Nitrate/Nitrite as N (mg/L)	0.0323	0.01	0.07	0.03

(C:\LOTUS\2213\GP-APB12.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B13 – PROCESS POND SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Biological Oxygen Demand (ppm)	3580	8	34.5	138
Total Organic Carbon (weight %)	12.7	10.5	3.8	8.4
Total Phosphorous (ppm)	15.4	61.9	2970	4.3
Total Kjeldahl Nitrogen (ppm)	4530	2070	1570	2000
% Solids	30.9	36.4	72.5	54.8
% Water	53.5	52.2	26	23.9
Oil & Grease (%)	15.6	11.4	1.5	21.3
BTU Content (BTU/LB) as recieved basis	4399	4653	1381	2669
Total Sulphur (weight %)	1.74	2.3	1.72	2.12
Specific Gravity	1.15	1.26	1.64	1.32
pH	7.96	7.42	7.42	7.34
Electrical Conductance (umhos/cm)	4760	4080	1040	12940
Particle size % Sand	37	57	78	67
Particle size % Silt	59	38	15	29
Particle size % Clay	4	5	7	4
Free Liquid (%)	1	0	0	0
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	no	no	no	no
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	160	520	680	720
Magnesium (ppm)	24.4	293	29.3	73.2
Sodium (ppm)	540	77.8	234	1928
Potassium (ppm)	82.2	28.2	79	205
Chloride (ppm)	444	17.8	234	4120
Sulphate (ppm)	48.4	2100	154	548
Bicarbonate (ppm)	0	467	714	1
Nitrate as N (ppm)	1	1	1	2
Sulfide (ppm)	1400	2600	920	200
Leachate Analysis				
Arsenic (mg/L)	0.013	0.011	0.13	0.016
Barium (mg/L)	0.87	0.26	0.19	1.33
Boron (mg/L)	0.33	0.17	0.5	0.51
Cadmium (mg/L)	<0.001	<0.001	<0.001	<0.001
Chromium (mg/L)	<0.001	<0.001	0.005	0.16
Lead (mg/L)	<0.01	<0.01	<0.01	<0.01
Mercury (ug/L)	0.05	0.05	0.05	0.13
Selenium (mg/L)	<0.0002	<0.0002	<0.0002	<0.0002
Cyanide (mg/L)	0.004	<0.002	<0.002	0.009
Nitrate/Nitrite as N (mg/L)	0.05	0.05	0.05	0.1

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B13 – PROCESS POND SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM			
	SAMPLE #5	SAMPLE #6	SAMPLE #7	SAMPLE #8
Biological Oxygen Demand (ppm)	18500	2390	630	675
Total Organic Carbon (weight %)	3.4	10.2	0.22	0.03
Total Phosphorous (ppm)	900	450	270	160
Total Kjeldahl Nitrogen (ppm)	4320	2535	87	267
% Solids	35.6	43.9	45.3	84.5
% Water	62.4	7.5	15.9	16.2
Oil & Grease (%)	0.4	6.1	0.08	0.05
BTU Content (BTU/LB) as recieved basis	879	1646	308	0
Total Sulphur (weight %)	0.58	0.67	0.02	0.03
Specific Gravity	1.23	1.8	1.9	1.9
pH	7.81	9.3	6.9	8.4
Electrical Conductance (umhos/cm)	5340	4400	860	1560
Particle size % Sand	26	82	82	94
Particle size % Silt	60	8	10	1
Particle size % Clay	14	10	8	5
Free Liquid (%)	0	2.5	0	0
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	no	no	no	no
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	160	40	60	20
Magnesium (ppm)	49	12.2	12.2	12.2
Sodium (ppm)	160	229	36.6	220
Potassium (ppm)	10.9	35.2	25	10.9
Chloride (ppm)	32.4	374	18.6	67.6
Sulphate (ppm)	14	200	230	131
Bicarbonate (ppm)	3080	2400	160	670
Nitrate as N (ppm)	0.208	0.98	0.34	0.26
Sulfide (ppm)	2000	145	186	227
Leachate Analysis				
Arsenic (mg/L)	0.023	0.0012	0.002	0.0012
Barium (mg/L)	3.11	0.72	0.15	0.28
Boron (mg/L)	0.14	0.29	0.03	0.02
Cadmium (mg/L)	<0.001	<0.001	<0.001	<0.001
Chromium (mg/L)	0.004	0.007	0.002	0.003
Lead (mg/L)	<0.01	<0.01	<0.01	<0.01
Mercury (ug/L)	0.24	0.28	0.1	0.1
Selenium (mg/L)	<0.0002	<0.0002	<0.0002	<0.0002
Cyanide (mg/L)	0.012	0.012	<0.002	<0.002
Nitrate/Nitrite as N (mg/L)	0.01	0.05	0.017	0.013

(C:\LOTUS\B2213\APB13.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B13 – PROCESS POND SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Biological Oxygen Demand (ppm)				
Total Organic Carbon (weight %)			2.2	
Total Phosphorous (ppm)				
Total Kjeldahl Nitrogen (ppm)	1763	449	950	
% Solids	28.9	17.1		31.5
% Water	70	82	52.4	59.5
Oil & Grease (%)	1.1	0.8	1.9	0.04
BTU Content (BTU/LB) as recieved basis				
Total Sulphur (weight %)	1.8	1.1	0.35	
Specific Gravity				
pH	6.3	6.5	8	
Electrical Conductance (umhos/cm)	14.2	11.9	20	
Particle size % Sand				
Particle size % Silt				
Particle size % Clay				
Free Liquid (%)				
Flashpoint (Centigrade)				
Flammability				
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	7160	5980		
Magnesium (ppm)	7782	7725		
Sodium (ppm)	5640	5600		
Potassium (ppm)				
Chloride (ppm)				6500
Sulphate (ppm)				
Bicarbonate (ppm)				
Nitrate as N (ppm)			0.4	
Sulfide (ppm)				2655
Leachate Analysis				
Arsenic (mg/L)				
Barium (mg/L)				
Boron (mg/L)				
Cadmium (mg/L)				
Chromium (mg/L)				
Lead (mg/L)				
Mercury (ug/L)				
Selenium (mg/L)				
Cyanide (mg/L)				
Nitrate/Nitrite as N (mg/L)				

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B13 – PROCESS POND SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA				
	SAMPLE #5	SAMPLE #6	SAMPLE #7	SAMPLE #8	SAMPLE #9
Biological Oxygen Demand (ppm)					
Total Organic Carbon (weight %)				5.14	
Total Phosphorous (ppm)					
Total Kjeldahl Nitrogen (ppm)		1017	1468	1450	
% Solids		29.6	33.8		
% Water		68	64	42.4	
Oil & Grease (%)	3.0	2.4	2.2	2.1	
BTU Content (BTU/LB) as recieved basis					
Total Sulphur (weight %)	2.75	3	1.8	0.75	
Specific Gravity					
pH	7.4	6.7	6.4	8.33	
Electrical Conductance (umhos/cm)		356	133	4.9	
Particle size % Sand					
Particle size % Silt					
Particle size % Clay					
Free Liquid (%)					
Flashpoint (Centigrade)					
Flammability					
Soluble Ions (On Total Sample Basis)					
Calcium (ppm)	19400				
Magnesium (ppm)	5000				
Sodium (ppm)					
Potassium (ppm)					
Chloride (ppm)					1310
Sulphate (ppm)	4376				7.6
Bicarbonate (ppm)					
Nitrate as N (ppm)				0.19	
Sulfide (ppm)					
Leachate Analysis					
Arsenic (mg/L)					
Barium (mg/L)					
Boron (mg/L)					
Cadmium (mg/L)					
Chromium (mg/L)					
Lead (mg/L)					
Mercury (ug/L)					
Selenium (mg/L)					
Cyanide (mg/L)					
Nitrate/Nitrite as N (mg/L)					

(C:\LOTUS\2213\APB13.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B13 – PROCESS POND SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	2888.11	8	18500	5642.91
Total Organic Carbon (weight %)	5.24	0.03	12.7	4.30
Total Phosphorous (ppm)	870.18	4.3	3000	1160.51
Total Kjeldahl Nitrogen (ppm)	1698.40	87	4530	1256.29
% Solids	34.91	0	84.5	22.64
% Water	46.70	7.5	82	21.60
Oil & Grease (%)	7341.66	0.1	60800	18936.76
BTU Content (BTU/LB) as recieved basis	1905.11	0	4653	1578.00
Total Sulphur (weight %)	1.32	0.02	3	0.93
Specific Gravity	1.51	1.15	1.9	0.28
pH	7.52	6.3	9.3	0.81
Electrical Conductance (umhos/cm)	2491.33	4.9	12940	3360.01
Particle size % Sand	62.22	26	94	22.79
Particle size % Silt	27.22	1	60	20.31
Particle size % Clay	10.56	4	38	10.18
Free Liquid (%)	0.39	0	2.5	0.81
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	2911.00	20	19400	5500.06
Magnesium (ppm)	1777.46	12.2	7782	2993.31
Sodium (ppm)	1354.04	36.6	5640	2072.59
Potassium (ppm)	57.71	10.9	205	57.54
Chloride (ppm)	1122.20	17.8	6500	1965.27
Sulphate (ppm)	805.91	7.6	4376	1278.02
Bicarbonate (ppm)	1013.38	1	3080	1037.52
Nitrate as N (ppm)	0.76	0.19	2	0.52
Sulfide (ppm)	1045.30	120	2655	992.49
Leachate Analysis				
Arsenic (mg/L)	0.0224	0.0012	0.13	0.0387
Barium (mg/L)	0.8811	0.15	3.11	0.8803
Boron (mg/L)	0.2356	0.02	0.51	0.1733
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	0.0302	0.002	0.16	0.0581
Lead (mg/L)	0.0144	0.01	0.05	0.0126
Mercury (ug/L)	0.1478	0.05	0.33	0.1015
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	0.0093	0.004	0.012	0.0033
Nitrate/Nitrite as N (mg/L)	0.0433	0.01	0.1	0.0262

(C:\LOTUS\92213\APB13.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B14 – SULFINOL SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	50.1	1790	10950
Total Organic Carbon (weight %)	49.5	11.6	21.7
Total Phosphorous (ppm)	16.5	11.5	790
Total Kjeldahl Nitrogen (ppm)	101000	49500	8890
% Solids	0.35	0.06	51.9
% Water	A.P.	A.P.	29.8
Oil & Grease (ppm)	A.P.	6950	95200
BTU Content (BTU/LB) as recieved basis	10782	514	4404
Total Sulphur (weight %)	2.35	9.86	0.65
Specific Gravity	1.11	1.15	1.2
pH	9.67	10.1	10.4
Electrical Conductance (umhos/cm)	6980	1370	1560
Particle size % Sand	I.S.	I.S.	I.S.
Particle size % Silt	I.S.	I.S.	I.S.
Particle size % Clay	I.S.	I.S.	I.S.
Free Liquid (%)	100	98	10
Flashpoint (Centigrade)	N.A.	>128	N.A.
Flammability	no	N/A	no
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	140	112	40
Magnesium (ppm)	73.2	6	12
Sodium (ppm)	2300	1200	50.4
Potassium (ppm)	125	4	8.6
Chloride (ppm)	270	450	3
Sulphate (ppm)	2920	20	15.6
Bicarbonate (ppm)	0	116	5740
Nitrate as N (ppm)	10	0.3	0.074
Sulfide (ppm)	5600	512	440
Leachate Analysis			
Arsenic (mg/L)	0.0013	N.T.	0.0005
Barium (mg/L)	0.01	N.T.	0.68
Boron (mg/L)	0.62	N.T.	0.11
Cadmium (mg/L)	<0.001	N.T.	0.015
Chromium (mg/L)	1.12	N.T.	0.016
Lead (mg/L)	0.05	N.T.	2.71
Mercury (ug/L)	0.05	N.T.	0.23
Selenium (mg/L)	<0.0002	N.T.	<0.0002
Cyanide (mg/L)	0.13	N.T.	0.003
Nitrate/Nitrite as N (mg/L)	0.5	N.T.	0.004

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B14 – SULFINOL SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Biological Oxygen Demand (ppm)				
Total Organic Carbon (weight %)	10.3			
Total Phosphorous (ppm)				
Total Kjeldahl Nitrogen (ppm)	1900			
% Solids			4.5	0.88
% Water	49.9	0.4	92.3	
Oil & Grease (ppm)	78000		13000	94000
BTU Content (BTU/LB) as recieved basis				
Total Sulphur (weight %)	2.94			
Specific Gravity				
pH	8.1		6.1	7.45
Electrical Conductance (umhos/cm)				
Particle size % Sand				
Particle size % Silt				
Particle size % Clay				
Free Liquid (%)				
Flashpoint (Centigrade)				
Flammability				
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)				
Magnesium (ppm)				
Sodium (ppm)				
Potassium (ppm)				
Chloride (ppm)				
Sulphate (ppm)				
Bicarbonate (ppm)				
Nitrate as N (ppm)				
Sulfide (ppm)			1460	980
Leachate Analysis				
Arsenic (mg/L)				
Barium (mg/L)				
Boron (mg/L)				
Cadmium (mg/L)				
Chromium (mg/L)				
Lead (mg/L)				
Mercury (ug/L)				
Selenium (mg/L)				
Cyanide (mg/L)				
Nitrate/Nitrite as N (mg/L)				

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B14 – SULFINOL SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	4263.37	50.1	10950	4781.22
Total Organic Carbon (weight %)	23.28	10.3	49.5	15.77
Total Phosphorous (ppm)	272.67	11.5	790	365.82
Total Kjeldahl Nitrogen (ppm)	40322.50	1900	101000	39466.05
% Solids	11.54	0.06	51.9	20.24
% Water	43.10	0.4	92.3	33.42
Oil & Grease (ppm)	57430.00	6950	95200	39266.57
BTU Content (BTU/LB) as recieved basis	5233.33	514	10782	4232.71
Total Sulphur (weight %)	3.95	0.65	9.86	3.51
Specific Gravity	1.15	1.11	1.2	0.04
pH	8.64	6.1	10.4	1.55
Electrical Conductance (umhos/cm)	3303.33	1370	6980	2600.95
Particle size % Sand	N/A	N/A	N/A	N/A
Particle size % Silt	N/A	N/A	N/A	N/A
Particle size % Clay	N/A	N/A	N/A	N/A
Free Liquid (%)	69.33	10	100	41.96
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	97.33	40	140	42.12
Magnesium (ppm)	30.40	6	73.2	30.36
Sodium (ppm)	1183.47	50.4	2300	918.47
Potassium (ppm)	45.87	4	125	55.99
Chloride (ppm)	241.00	3	450	183.64
Sulphate (ppm)	985.20	15.6	2920	1368.11
Bicarbonate (ppm)	1952.00	0	5740	2678.94
Nitrate as N (ppm)	3.46	0.074	10	4.63
Sulfide (ppm)	1798.40	440	5600	1935.80
Leachate Analysis				
Arsenic (mg/L)	0.0009	0.0005	0.0013	0.0004
Barium (mg/L)	0.3450	0.01	0.68	0.3350
Boron (mg/L)	0.3650	0.11	0.62	0.2550
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	0.5680	0.016	1.12	0.5520
Lead (mg/L)	1.3800	0.05	2.71	1.3300
Mercury (ug/L)	0.1400	0.05	0.23	0.0900
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	0.0665	0.003	0.13	0.0635
Nitrate/Nitrite as N (mg/L)	0.2520	0.004	0.5	0.2480

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B15 – UN–NEUTRALIZED SULPHUR POND SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	N.T.	N.T.	N.T.
Total Organic Carbon (weight %)	0.88	N.T.	N.T.
Total Phosphorous (ppm)	N.T.	N.T.	N.T.
Total Kjeldahl Nitrogen (ppm)	N.T.	N.T.	N.T.
% Solids	57.1	75.4	83.7
% Water	17.1	24.3	15.8
Oil & Grease (%)	0.03	0.03	0.001
BTU Content (BTU/LB) as recieved basis	1668	231	0
Total Sulphur (weight %)	46.1	0.09	2.92
Specific Gravity	1.18	1.91	1.78
pH	7.2	3.43	5.64
Electrical Conductance (umhos/cm)	4980	3160	5200
Particle size % Sand	62	46	64
Particle size % Silt	28	26	28
Particle size % Clay	10	28	8
Free Liquid (%)	0	0	1
Flashpoint (Centigrade)	N.T.	N.T.	N.T.
Flammability	yes	N.T.	N.T.
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	1080	520	1120
Magnesium (ppm)	195	98	195
Sodium (ppm)	27.4	18.3	9.16
Potassium (ppm)	6.3	6.26	3.13
Chloride (ppm)	9	5.2	30
Sulphate (ppm)	N.T.	2300	3500
Bicarbonate (ppm)	325	0	0
Nitrate as N (ppm)	N.T.	N.T.	N.T.
Sulfide (ppm)	40	N.T.	N.T.
Leachate Analysis			
Arsenic (mg/L)	N.T.	0.0011	0.0006
Barium (mg/L)	N.T.	0.04	0.03
Boron (mg/L)	N.T.	0.1	0.02
Cadmium (mg/L)	N.T.	<0.001	0.003
Chromium (mg/L)	N.T.	<0.001	0.004
Lead (mg/L)	N.T.	<0.01	0.03
Mercury (ug/L)	N.T.	0.1	0.1
Selenium (mg/L)	N.T.	<0.0002	0.0003
Cyanide (mg/L)	N.T.	<0.002	<0.002
Nitrate/Nitrite as N (mg/L)	N.T.	0.015	0.019

(C:\LOTUS\2213\GP-AP815.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B15 – UN–NEUTRALIZED SULPHUR POND SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Biological Oxygen Demand (ppm)				
Total Organic Carbon (weight %)	1.7	1.8	1.6	2.09
Total Phosphorous (ppm)				
Total Kjeldahl Nitrogen (ppm)	1600	1700	1600	1770
% Solids				
% Water	44.3	45.2	44.8	38.2
Oil & Grease (%)	1	0.8	0.8	0.8
BTU Content (BTU/LB) as recieved basis				
Total Sulphur (weight %)	0.69	0.52	0.74	1.23
Specific Gravity				
pH	3	3	3	3.47
Electrical Conductance (umhos/cm)	6000	6000	6100	2100
Particle size % Sand				
Particle size % Silt				
Particle size % Clay				
Free Liquid (%)				
Flashpoint (Centigrade)				
Flammability				
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)				
Magnesium (ppm)				
Sodium (ppm)				
Potassium (ppm)				
Chloride (ppm)				
Sulphate (ppm)				
Bicarbonate (ppm)				
Nitrate as N (ppm)	0.4	0.5	0.5	0.009
Sulfide (ppm)				
Leachate Analysis				
Arsenic (mg/L)				
Barium (mg/L)				
Boron (mg/L)				
Cadmium (mg/L)				
Chromium (mg/L)				
Lead (mg/L)				
Mercury (ug/L)				
Selenium (mg/L)				
Cyanide (mg/L)				
Nitrate/Nitrite as N (mg/L)				

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B15 – UN-NEUTRALIZED SULPHUR POND SLUDGE

PARAMETER	STATISTICAL PRARMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	N/A	N/A	N/A	N/A
Total Organic Carbon (weight %)	1.61	0.88	2.09	0.40
Total Phosphorous (ppm)	N/A	N/A	N/A	N/A
Total Kjeldahl Nitrogen (ppm)	1667.50	1600	1770	71.89
% Solids	72.07	57.1	83.7	11.11
% Water	32.81	15.8	45.2	12.35
Oil & Grease (%)	0.49	0.001	1	0.42
BTU Content (BTU/LB) as recieved basis	633.00	0	1668	737.91
Total Sulphur (weight %)	7.47	0.09	46.1	15.79
Specific Gravity	1.62	1.18	1.91	0.32
pH	4.11	3	7.2	1.53
Electrical Conductance (umhos/cm)	4791.43	2100	6100	1451.18
Particle size % Sand	57.33	46	64	8.06
Particle size % Silt	27.33	26	28	0.94
Particle size % Clay	15.33	8	28	8.99
Free Liquid (%)	0.33	0	1	0.47
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	906.67	520	1120	273.90
Magnesium (ppm)	162.67	98	195	45.73
Sodium (ppm)	18.29	9.16	27.4	7.45
Potassium (ppm)	5.23	3.13	6.3	1.49
Chloride (ppm)	14.73	5.2	30	10.91
Sulphate (ppm)	2900.00	2300	3500	600.00
Bicarbonate (ppm)	108.33	0	325	153.21
Nitrate as N (ppm)	0.35	0.009	0.5	0.20
Sulfide (ppm)	40.00	40	40	0.00
Leachate Analysis				
Arsenic (mg/L)	0.0009	0.0006	0.0011	0.0002
Barium (mg/L)	0.0350	0.03	0.04	0.0050
Boron (mg/L)	0.0600	0.02	0.1	0.0400
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	N/A	N/A	N/A	N/A
Lead (mg/L)	N/A	N/A	N/A	N/A
Mercury (ug/L)	0.1000	0.1	0.1	0.0000
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	N/A	N/A	N/A	N/A
Nitrate/Nitrite as N (mg/L)	0.0170	0.015	0.019	0.0020

(C:\LOTUS\3213\SP-AP815.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B16 – WATER TREATMENT SLUDGE

PARAMETER	1989/90 SAMPLING PROGRAM		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Biological Oxygen Demand (ppm)	N.T.	2552	N.T.
Total Organic Carbon (weight %)	N.T.	13.7	N.T.
Total Phosphorous (ppm)	N.T.	683	N.T.
Total Kjeldahl Nitrogen (ppm)	N.T.	3230	N.T.
% Solids	I.S.	51.9	69.8
% Water	I.S.	45.4	29.9
Oil & Grease (ppm)	62	10700	197
BTU Content (BTU/LB) as recieved basis	954	2431	1229
Total Sulphur (weight %)	0.61	1.64	0.26
Specific Gravity	I.S.	1.16	1.59
pH	6.88	7.77	10.1
Electrical Conductance (umhos/cm)	280	580	1020
Particle size % Sand	I.S.	80	90
Particle size % Silt	I.S.	18	8
Particle size % Clay	I.S.	2	2
Free Liquid (%)	I.S.	0	11
Flashpoint (Centigrade)	N/A	N/A	N.T.
Flammability	no	no	N.T.
Soluble Ions (On Total Sample Basis)			
Calcium (ppm)	56	32	20
Magnesium (ppm)	14.6	4.9	12
Sodium (ppm)	22.9	59.5	211
Potassium (ppm)	3.13	7.82	4.69
Chloride (ppm)	44.6	10.8	3
Sulphate (ppm)	N.T.	60	15
Bicarbonate (ppm)	28.1	253	456
Nitrate as N (ppm)	N.T.	0.024	282
Sulfide (ppm)	120	910	N.T.
Leachate Analysis			
Arsenic (mg/L)	N.T.	0.0024	0.0008
Barium (mg/L)	N.T.	0.62	0.18
Boron (mg/L)	N.T.	0.07	0.02
Cadmium (mg/L)	N.T.	<0.001	0.023
Chromium (mg/L)	N.T.	0.012	0.004
Lead (mg/L)	N.T.	<0.01	<0.01
Mercury (ug/L)	N.T.	0.1	0.16
Selenium (mg/L)	N.T.	<0.0002	<0.0002
Cyanide (mg/L)	N.T.	<0.002	<0.002
Nitrate/Nitrite as N (mg/L)	N.T.	0.001	0.014

(C:\LOTUS\B213\SP-AP516.WK1)

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B16 – WATER TREATMENT SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Biological Oxygen Demand (ppm)				
Total Organic Carbon (weight %)		83.5	170	
Total Phosphorous (ppm)				
Total Kjeldahl Nitrogen (ppm)				
% Solids		1.3	1.9	2.8
% Water				
Oil & Grease (ppm)				
BTU Content (BTU/LB) as recieved basis				
Total Sulphur (weight %)	2.4			
Specific Gravity				
pH	7	5.7	6	6.4
Electrical Conductance (umhos/cm)				
Particle size % Sand				
Particle size % Silt				
Particle size % Clay				
Free Liquid (%)				
Flashpoint (Centigrade)				
Flammability				
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	10800	12500	11700	8300
Magnesium (ppm)	3800			
Sodium (ppm)				
Potassium (ppm)				
Chloride (ppm)	9			
Sulphate (ppm)	3059	8640	12300	16810
Bicarbonate (ppm)				
Nitrate as N (ppm)				
Sulfide (ppm)				
Leachate Analysis				
Arsenic (mg/L)				
Barium (mg/L)				
Boron (mg/L)				
Cadmium (mg/L)				
Chromium (mg/L)				
Lead (mg/L)				
Mercury (ug/L)				
Selenium (mg/L)				
Cyanide (mg/L)				
Nitrate/Nitrite as N (mg/L)				

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

TABLE B16 – WATER TREATMENT SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Biological Oxygen Demand (ppm)	850.67	0	2552	1203.02
Total Organic Carbon (weight %)	53.44	0	170	66.00
Total Phosphorous (ppm)	227.67	0	683	321.97
Total Kjeldahl Nitrogen (ppm)	1076.67	0	3230	1522.64
% Solids	18.24	0	69.8	27.38
% Water	25.10	0	45.4	18.84
Oil & Grease (ppm)	3653.00	62	10700	4983.29
BTU Content (BTU/LB) as recieved basis	1538.00	954	2431	641.35
Total Sulphur (weight %)	1.23	0.26	2.4	0.85
Specific Gravity	0.92	0	1.59	0.67
pH	7.12	5.7	10.1	1.37
Electrical Conductance (umhos/cm)	626.67	280	1020	303.90
Particle size % Sand	56.67	0	90	40.28
Particle size % Silt	8.67	0	18	7.36
Particle size % Clay	1.33	0	2	0.94
Free Liquid (%)	3.67	0	11	5.19
Flashpoint (Centigrade)	N/A	N/A	N/A	N/A
Flammability	N/A	N/A	N/A	N/A
Soluble Ions (On Total Sample Basis)				
Calcium (ppm)	6201.14	20	12500	5470.64
Magnesium (ppm)	957.88	4.9	3800	1640.91
Sodium (ppm)	97.80	22.9	211	81.43
Potassium (ppm)	5.21	3.13	7.82	1.95
Chloride (ppm)	16.85	3	44.6	16.28
Sulphate (ppm)	5840.57	0	16810	6314.28
Bicarbonate (ppm)	245.70	28.1	456	174.77
Nitrate as N (ppm)	70.51	0	282	122.11
Sulfide (ppm)	343.33	0	910	403.68
Leachate Analysis				
Arsenic (mg/L)	0.0016	0.0008	0.0024	0.0008
Barium (mg/L)	0.4000	0.18	0.6200	0.2200
Boron (mg/L)	0.0450	0.02	0.0700	0.0250
Cadmium (mg/L)	N/A	N/A	N/A	N/A
Chromium (mg/L)	0.0080	0.004	0.0120	0.0040
Lead (mg/L)	N/A	N/A	N/A	N/A
Mercury (ug/L)	0.1300	0.1	0.1600	0.0300
Selenium (mg/L)	N/A	N/A	N/A	N/A
Cyanide (mg/L)	N/A	N/A	N/A	N/A
Nitrate/Nitrite as N (mg/L)	0.0075	0.001	0.0140	0.0065

A.P. – Analytical Problems / I.S. – Insufficient Samples / N/A – Not Applicable / N.T. – Not Tested

APPENDIX C

ADDITIONAL ANALYTICAL DATA

TABLE C1 – (PREVIOUS RESULTS) FLARE KNOCK–OUT SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Ash content (%)				1.95
Total Disolved Solids (ppm)			18300	
Aluminum (ppm)	2150	1820		3680
Iron (ppm)	24200			
Nickel (ppm)	13.5	0.05	1.5	50
Vanadium (ppm)			14	
Zinc (ppm)			345	
Total Phenol (ppm)			0.5	
Naphthalene (ppm)	97	42		185
Phenanthrene (ppm)	163	38		244
Total Extractable Hydrocarbon (%)		1.93	1.75	
Arsenic (mg/L)	8.4	0.06	0.02	10.80
Cadmium (mg/L)	0.1	0.1	0.001	0.01
Chromium (mg/L)	587	0.004	45.3	1290.00
Lead (mg/L)	35	0.001	1.03	80.10
Mercury (uç'L)	0.13	0.053	0.03	0.85

(C:\LOTUS\2213\GP-APC01.WK1)

TABLE C1 – (PREVIOUS RESULTS) FLARE KNOCK-OUT SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Ash content (%)	1.95	1.95	1.95	0.00
Total Disolved Solids (ppm)	18300.00	18300	18300	0.00
Aluminum (ppm)	2550.00	1820	3680	810.31
Iron (ppm)	12100.00	0	24200	12100.00
Nickel (ppm)	16.26	0.05	50	20.17
Vanadium (ppm)	14.00	14	14	0.00
Zinc (ppm)	345.00	345	345	0.00
Total Phenol (ppm)	0.50	0.5	0.5	0.00
Naphthalene (ppm)	108.00	42	185	58.90
Phenanthrene (ppm)	148.33	38	244	84.74
Total Extractable Hydrocarbon (%)	1.84	1.75	1.93	0.09
Arsenic (mg/L)	4.82	0.02	10.8	4.85
Cadmium (mg/L)	0.05	0.001	0.1	0.05
Chromium (mg/L)	480.58	0.004	1290	521.27
Lead (mg/L)	29.03	0.001	80.1	32.67
Mercury (ug/L)	0.27	0.03	0.85	0.34

(C:\LOTUS\2213\GP-APC01 WK1)

TABLE C2 – (PREVIOUS RESULTS) COOLING TOWER SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA				
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5
Chemical Oxygen Demand (ppm)	194	19			
Threshold Odour Number	1	1			
Aluminum (ppm)	3.08	0.11			
Beryllium (ppm)	0.001	0.001			
Cobalt (ppm)	0.002	0.001			
Copper (ppm)	1.1	0.004	45	150	250
Iron (ppm)	40	0.01			
Lithium (ppm)	0.018	0.016			
Manganese (ppm)	16.9	8.9			
Nickel (ppm)	0.038	0.041	18	35	0.36
Silicon (ppm)	11.6	5			
Silver (ppm)	0.006	0.001			
Strontium (ppm)	1.07	0.84			
Vanadium (ppm)	0.02	0.002			
Zinc (ppm)	4.62	0.096	520	9000	10500
Residual Chlorine (mg/l)	0.05				
Total Hydrocarbons (ppm)			168.0	159.0	160.0
Arsenic (mg/L)	1.05	0.011			
Barium (mg/L)	0.41	0.27			
Boron (mg/L)	0.13	0.1			
Cadmium (mg/L)	0.003	0.001	0.2	0.2	0.2
Lead (mg/L)	0.002	0.002	19	0.38	0.5
Mercury (ug/L)	0.1	0.05	0.28	0.14	0.18
Selenium (mg/L)	0.0005	0.0005			

TABLE C2 – (PREVIOUS RESULTS) COOLING TOWER SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Chemical Oxygen Demand (ppm)	106.50	19	194	87.50
Threshold Odour Number	1.00	1	1	0.00
Aluminum (ppm)	1.60	0.11	3.08	1.49
Beryllium (ppm)	0.00	0	0.001	0.00
Cobalt (ppm)	0.00	0	0.002	0.00
Copper (ppm)	89.22	0.004	250	97.18
Iron (ppm)	13.34	0	40	18.85
Lithium (ppm)	0.01	0	0.018	0.01
Manganese (ppm)	8.60	0	16.9	6.90
Nickel (ppm)	10.69	0.038	35	13.99
Silicon (ppm)	8.30	5	11.6	3.30
Silver (ppm)	0.00	0	0.006	0.00
Strontium (ppm)	0.96	0.84	1.07	0.11
Vanadium (ppm)	0.01	0	0.02	0.01
Zinc (ppm)	4004.94	0.096	10500	4718.53
Residual Chlorine (mg/l)	0.05	0.05	0.05	0.00
Total Hydrocarbons (ppm)	162.33	159.0	168.0	4.03
Arsenic (mg/L)	0.53	0.0	1.1	0.52
Barium (mg/L)	0.23	0.0	0.4	0.17
Boron (mg/L)	0.08	0.0	0.1	0.06
Cadmium (mg/L)	0.12	0.0	0.2	0.10
Lead (mg/L)	3.98	0.0	19.0	7.51
Mercury (ug/L)	0.15	0.1	0.3	0.08
Selenium (mg/L)	0.00	0.0	0.0	0.00

(C:\LOTUS\22133\SP-APC02.WK1)

TABLE C3 – (PREVIOUS RESULTS) PROCESS FLOOR DRAIN SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA				
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5
Ash Content (%)		24.64		18.1	67
Aluminum (ppm)			12000		
Chromium (+6) (ppm)	141	0.001		0.003	
Cobalt (ppm)		0.15	4.2	0.03	
Copper (ppm)		0.001	36	0.001	
Iron (ppm)			11000		
Manganese (ppm)					
Molybdenum (ppm)		0.026	1.1	0.022	
Nickel (ppm)		0.18	14	0.059	
Silver (ppm)		0.001		0.001	
Thallium (ppm)		0.001	50	0.001	
Vanadium(ppm)		0.014	25	0.004	
Zinc (ppm)	7.04	0.68	170	0.48	
Total Hydrocarbons (%)	2.3				
Sulfinol (Sulfolane) (ppm)				12	
DIPA (ppm)				10	
MEA (ppm)			0.01		
Total Phenol (ppm)	83		0.33	0.03	
BTEX (ppm)	125				
Naphthalene (ppm)	12.5		2.9		
Flouranthene (ppm)			1		
Fluorene (ppm)			2.4		
Pyrene (ppm)			2.3		
Phenanthrene/Anthancene (ppm)			5		
Arsenic (mg/L)	4.94	0.0038	39	0.0037	0.048
Barium (mg/L)	250	2.51	170	0.11	
Boron (mg/L)	178		52		
Cadmium (mg/L)	1.55		0.58	0.001	
Chromium (mg/L)		0.003	180	0.003	
Lead (mg/L)	155	0.002	17	0.01	
Mercury (ug/L)	1.35	0.08	0.17	0.0001	
Selenium (mg/L)		0.0002	0.012	0.0002	
Cyanide (mg/L)		0.005	14	0.001	0.03

TABLE C3 – (PREVIOUS RESULTS) PROCESS FLOOR DRAIN SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Ash Content (%)	36.58	18.1	67	21.68
Aluminum (ppm)	12000.00	12000	12000	0.00
Chromium (+6) (ppm)	47.00	0.001	141	66.47
Cobalt (ppm)	1.46	0.03	4.2	1.94
Copper (ppm)	12.00	0.001	36	16.97
Iron (ppm)	11000.00	11000	11000	0.00
Manganese (ppm)	0.00	0	0	0.00
Molybdenum (ppm)	0.38	0.022	1.1	0.51
Nickel (ppm)	4.75	0.059	14	6.54
Silver (ppm)	0.00	0	0.001	0.00
Thallium (ppm)	16.67	0.001	50	23.57
Vanadium(ppm)	8.34	0.004	25	11.78
Zinc (ppm)	44.55	0.48	170	72.48
Total Hydrocarbons (%)	2.30	2.3	2.3	0.00
Sulfinol (Sulfolane) (ppm)	12.00	12	12	0.00
DIPA (ppm)	10.00	10	10	0.00
MEA (ppm)	0.01	0.01	0.01	0.00
Total Phenol (ppm)	27.79	0.03	83	39.04
BTEX (ppm)	125.00	125	125	0.00
Naphthalene (ppm)	7.70	2.9	12.5	4.80
Flouranthene (ppm)	1.00	1	1	0.00
Fluorene (ppm)	2.40	2.4	2.4	0.00
Pyrene (ppm)	1.15	0	2.3	1.15
Phenanthrene/Anthancene (ppm)	2.50	0	5	2.50
Arsenic (mg/L)	8.80	0.0037	39	15.22
Barium (mg/L)	105.6550	0.11	250	108.11
Boron (mg/L)	115.0000	52	178	63.00
Cadmium (mg/L)	0.7103	0.001	1.55	0.64
Chromium (mg/L)	60.0020	0.003	180	84.85
Lead (mg/L)	43.0030	0.002	155	65.03
Mercury (ug/L)	0.4000	0.0001	1.35	0.55
Selenium (mg/L)	0.0041	0.0002	0.012	0.01
Cyanide (mg/L)	3.5090	0.001	14	6.06

TABLE C4 – (PREVIOUS RESULTS) DEA AMINE SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA				
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5
Carbon–Nitrogen Ratio			44.1		
Copper (ppm)				340	175
Nickel (ppm)				90	80
Vanadium (ppm)		620			
Zinc (ppm)				675	570
ORGANIC Matter (%)			33.4		
Total Hydrocarbons (ppm)				1210	672
PCB's (ppm)					15
Sulfinol (ppm)			92		
DEA (%)	54.46		0.58	80	
MEA (ppm)			105		
DEG (ppm)			261		
Amine Degradation Products (ppm)	3.16%				
Total Phenol (ppm)			13.5		
BTEX (ppm)			4		
PAH's (ppm)					825
Paraffins/Olefins (ppm)				8000	731
Naphthalene (ppm)			93		10
Flourene (ppm)			728		
Phenanthrene (ppm)			48		
Thiophenes (ppm)					169
Pyrene (ppm)					169
Cadmium (mg/L)				1.1	9.1
Chromium (mg/L)				67	400
Lead (mg/L)				40	1050
Mercury (ug/L)				0.6	80
Cyanide (mg/L)		10			

(C:\LOTUS\2213\3P-APC04.WK1)

TABLE C4 – (PREVIOUS RESULTS) DEA AMINE SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Carbon–Nitrogen Ratio	44.1	44.1	44.1	0.0000
Copper (ppm)	257.5	175	340	82.5
Nickel (ppm)	85	80	90	5
Vanadium (ppm)	620	620	620	0
Zinc (ppm)	622.5	570	675	52.5
ORGANIC Matter (%)	33.4	33.4	33.4	0.00000020
Total Hydrocarbons (ppm)	941	672	1210	269
PCB's (ppm)	15	15	15	0
Sulfinol (ppm)	92	92	92	0
DEA (%)	45.01	0.58	80	33.10
MEA (ppm)	105	105	105	0
DEG (ppm)	261	261	261	0
Amine Degradation Products (ppm)	0	0	0	0
Total Phenol (ppm)	13.5	13.5	13.5	0
BTEX (ppm)	4	4	4	0
PAH's (ppm)	825	825	825	0
Paraffins/Olefins (ppm)	4365.5	731	8000	3634.5
Naphthalene (ppm)	51.5	10	93	41.5
Flourene (ppm)	728	728	728	0
Phenanthrene (ppm)	48	48	48	0
Thiophenes (ppm)	169	169	169	0
Pyrene (ppm)	169	169	169	0
Cadmium (mg/L)	5.1	1.1	9.1	4
Chromium (mg/L)	233.5	67	400	166.5
Lead (mg/L)	545	40	1050	505
Mercury (ug/L)	40.3	0.6	80	39.7
Cyanide (mg/L)	10	10	10	0

TABLE C5 – (PREVIOUS RESULTS) MEA AMINE SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Ammonia–N (ppm)	110	190	120	
Carbon–Nitrogen Ratio				34.3
Aluminum (ppm)		4000	8900	
Cobalt (ppm)	0.43	0.39	0.5	
Copper (ppm)	8.9	7.5	7.5	
Iron (ppm)	2000	2000	2000	
Manganese (ppm)	29	29	25	
Molybdenum (ppm)	1.7	1.1	1.6	
Nickel (ppm)	3.9	5	5.4	
Thallium (ppm)	250	250	250	
Vanadium (ppm)	2.8	6.4	11	
Zinc (ppm)	24	3.6	11	
MEA (ppm)				10
Total Phenol (ppm)	1.4	1.3	1.4	
BTEX (ppm)				3.46
Naphthalene (ppm)				4.8
Phenanthrene (ppm)				11
Arsenic (mg/L)	0.68	0.71	0.74	
Barium (mg/L)	7.1	5.7	6.1	
Boron (mg/L)	1.7	0.2	0.14	
Cadmium (mg/L)	0.04	0.54	0.61	
Chromium (mg/L)	13	11	11	
Lead (mg/L)	4.6	1.9	6.4	
Mercury (ug/L)	0.06	0.06	0.06	
Selenium (mg/L)	0.04	0.04	0.04	
Cyanide (mg/L)	24	22	20	

(C:\LOTUS\93213\SP-APC05.WK1)

TABLE C5 – (PREVIOUS RESULTS) MEA AMINE SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA		
	SAMPLE #5	SAMPLE #6	SAMPLE #7
Ammonia–N (ppm)	60.6	8500	459
Carbon–Nitrogen Ratio			
Aluminum (ppm)	121	5	25.4
Cobalt (ppm)	1.2	0.1	0.1
Copper (ppm)	6.82	0.1	0.18
Iron (ppm)	4451	1	165
Manganese (ppm)	30	0.5	3.5
Molybdenum (ppm)	1.2	0.3	0.5
Nickel (ppm)	7.44	1	0.3
Thallium (ppm)	0.96	30	0.2
Vanadium (ppm)		0.05	0.4
Zinc (ppm)	4.57	2.7	2.2
MEA (ppm)			
Total Phenol (ppm)	5.81	88	59.8
BTEX (ppm)			
Naphthalene (ppm)			
Phenanthrene (ppm)			
Arsenic (mg/L)	0.78	0.33	0.27
Barium (mg/L)	2.07	0.05	1.06
Boron (mg/L)	0.5	6.7	54.4
Cadmium (mg/L)	1	0.05	0.2
Chromium (mg/L)	4.32	1.4	0.54
Lead (mg/L)	0.96	0.5	0.2
Mercury (ug/L)	0.005	0.015	0.005
Selenium (mg/L)	0.05	0.02	0.05
Cyanide (mg/L)	2.85	17	4.166

(C:\LOTUS\2213\BP-APC05.WK1)

TABLE C5 – (PREVIOUS RESULTS) MEA AMINE SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Ammonia–N (ppm)	1573.27	60.6	8500	3100.43
Carbon–Nitrogen Ratio	17.15	0	34.3	17.15
Aluminum (ppm)	2175.23	0	8900	3337.55
Cobalt (ppm)	0.45	0.1	1.2	0.37
Copper (ppm)	5.17	0.1	8.9	3.61
Iron (ppm)	1769.50	1	4451	1474.89
Manganese (ppm)	19.50	0.5	30	12.50
Molybdenum (ppm)	1.07	0.3	1.7	0.52
Nickel (ppm)	3.84	0.3	7.44	2.49
Thallium (ppm)	130.19	0.2	250	120.21
Vanadium (ppm)	3.44	0	11	4.06
Zinc (ppm)	8.01	2.2	24	7.72
MEA (ppm)	10.00	10	10	0.00
Total Phenol (ppm)	26.29	1.3	88	34.67
BTEX (ppm)	3.46	3.46	3.46	0.00
Naphthalene (ppm)	4.80	4.8	4.8	0.00
Phenanthrene (ppm)	11.00	11	11	0.00
Arsenic (mg/L)	0.59	0.27	0.78	0.20
Barium (mg/L)	3.68	0.05	7.1	2.72
Boron (mg/L)	10.61	0.14	54.4	19.72
Cadmium (mg/L)	0.41	0.04	1	0.35
Chromium (mg/L)	6.88	0.54	13	4.97
Lead (mg/L)	2.43	0.2	6.4	2.30
Mercury (ug/L)	0.03	0.005	0.06	0.03
Selenium (mg/L)	0.04	0.02	0.05	0.01
Cyanide (mg/L)	15.00	2.85	24	8.41

(C:\LOTUS\2213\SP-APC05.WK1)

TABLE C6 – (PREVIOUS RESULTS) DIGESTOR SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Ash Content (%)		17.3		
Total Disolved Solids (ppm)	3524	3456	2160	
Carbonates (ppm)			438	
Alkalinity (ppm)			1210	
Cobalt (ppm)				19.3
Copper (ppm)				35.4
Iron (ppm)			39.5	
Manganese (ppm)				82
Nickel (ppm)				34.3
Vanadium (ppm)				12.6
Zinc (ppm)			1493	
Total Hydrocarbons (mole fraction)				0.47
Sulfinol (ppm)		10.1		
DIPA (ppm)		4.9		
Total Phenol (ppm)		0.3		
BTEX (ppm)		0.33		
Barium (mg/L)				24
Boron (mg/L)				18.3
Cadmium (mg/L)				1.3
Chromium (mg/L)			310	72.3
Lead (mg/L)				12
Mercury (ug/L)				0.745

TABLE C6 – (PREVIOUS RESULTS) DIGESTOR SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Ash Content (%)	8.65	0	17.3	8.65
Total Disolved Solids (ppm)	2285.00	0	3524	1426.82
Carbonates (ppm)	438.00	438	438	0.00
Alkalinity (ppm)	1210.00	1210	1210	0.00
Cobalt (ppm)	9.65	0	19.3	9.65
Copper (ppm)	17.70	0	35.4	17.70
Iron (ppm)	39.50	39.5	39.5	0.00
Manganese (ppm)	82.00	82	82	0.00
Nickel (ppm)	17.15	0	34.3	17.15
Vanadium (ppm)	6.30	0	12.6	6.30
Zinc (ppm)	1493.00	1493	1493	0.00
Total Hydrocarbons (mole fraction)	0.47	0.47	0.47	0.00
Sulfinol (ppm)	5.05	0	10.1	5.05
DIPA (ppm)	4.90	4.9	4.9	0.00
Total Phenol (ppm)	0.30	0.3	0.3	0.00
BTEX (ppm)	0.33	0.33	0.33	0.00
Barium (mg/L)	24.00	24	24	0.00
Boron (mg/L)	18.30	18.3	18.3	0.00
Cadmium (mg/L)	1.30	1.3	1.3	0.00
Chromium (mg/L)	191.15	72.3	310	118.85
Lead (mg/L)	12.00	12	12	0.00
Mercury (ug/L)	0.37	0	0.745	0.37

(C:\LOTUS\2213\GP-APC06.WK1)

TABLE C7 – (PREVIOUS RESULTS) FLARE PIT SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Hydrogen Sulfide (ppm)			5000	
Cobalt (ppm)		24.7		
Copper (ppm)	0.01	31.2		70
Iron (ppm)				41560
Manganese (ppm)	4.106	200		550
Molybdenum (ppm)		8.2		14
Nickel (ppm)	0.056	27.8		50
Silver (ppm)	0.016			
Vanadium (ppm)		19		
Zinc (ppm)	0.077	86.3		446
Total Hydrocarbons (%)			0.5129	8.1
PAH's (ppm)			9.5	
Organosulphur Comp (ppm)			8	
Arsenic (mg/L)	0.06		0.003	
Barium (mg/L)	1.132	24		
Boron (mg/L)	0.1			80
Cadmium (mg/L)	0.0002	0.4	0.001	4.5
Chromium (mg/L)	0.015	19.9		1290
Lead (mg/L)	0.001	23		44
Mercury (ug/L)	0.00005	185	0.05	0.82
Selenium (mg/L)	0.05		0.0002	
Cyanide (mg/L)				2

TABLE C7 – (PREVIOUS RESULTS) FLARE PIT SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Hydrogen Sulfide (ppm)	5000.00	5000	5000	0.00
Cobalt (ppm)	12.35	0	24.7	12.35
Copper (ppm)	33.74	0.01	70	28.63
Iron (ppm)	41560.00	41560	41560	0.00
Manganese (ppm)	251.37	4.106	550	225.80
Molybdenum (ppm)	11.10	8.2	14	2.90
Nickel (ppm)	25.95	0.056	50	20.43
Silver (ppm)	0.01	0	0.016	0.01
Vanadium (ppm)	19.00	19	19	0.00
Zinc (ppm)	177.46	0.077	446	193.12
Total Hydrocarbons (%)	4.31	0.5129	8.1	3.79
PAH's (ppm)	9.50	9.5	9.5	0.00
Organosulphur Comp (ppm)	8.00	8	8	0.00
Arsenic (mg/L)	0.03	0.003	0.06	0.03
Barium (mg/L)	12.57	1.132	24	11.43
Boron (mg/L)	40.05	0.1	80	39.95
Cadmium (mg/L)	1.23	0.0002	4.5	1.90
Chromium (mg/L)	436.64	0.015	1290	603.47
Lead (mg/L)	22.33	0.001	44	17.97
Mercury (ug/L)	46.47	0.00005	185	79.98
Selenium (mg/L)	0.03	0.0002	0.05	0.02
Cyanide (mg/L)	2.00	2	2	0.00

(C:\LOTUS\221SNP-APC07.WK1)

TABLE C8 – (PREVIOUS RESULTS) GLYCOL SYSTEM SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA				
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5
Ash Content (%)	12	4.5	13.5	6.3	9.075
Corrosion Products (ppm)		44.8			22.4
Chromium (+6) (ppm)	0.25	1.6	50	0.9	13.1875
Iron (ppm)	12800	35000	1250	11800	15212.5
Nickel (ppm)	1.96		50		25.98
Thallium (ppm)	0.09				0.09
Total Hydrocarbons (ppm)	58000	1500	7500	2700	17425
Arsenic (mg/L)	2.01	0.15	0.2	0.02	0.595
Boron (mg/L)	0.3	0.3	0.1	4.36	1.265
Cadmium (mg/L)	0.3	0.3	0.1	4.36	1.265
Lead (mg/L)	< 0.01	< 0.001	700	260	. 240
Mercury (ug/L)	< 0.01	0.2	0.55	< 0.01	0.1875
Cyanide (mg/L)			0.35		0.175

(C:\LOTUS\ZI13\BP-APC08.WK1)

TABLE C8 – (PREVIOUS RESULTS) GLYCOL SYSTEM SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Ash Content (%)	4.5	13.5	3.77	3.37
Corrosion Products (ppm)	0	44.8	22.40	18.29
Chromium (+6) (ppm)	0.25	50	21.26	19.01
Iron (ppm)	1250	35000	12287.82	10990.56
Nickel (ppm)	1.96	50	24.02	19.61
Thallium (ppm)	0.09	0.09	0.00	0.00
Total Hydrocarbons (ppm)	1500	58000	23533.31	21048.84
Arsenic (mg/L)	0.02	2.01	0.82	0.73
Boron (mg/L)	0.1	4.36	1.79	1.60
Cadmium (mg/L)	0.1	4.36	1.79	1.60
Lead (mg/L)	0	700	286.01	255.81
Mercury (ug/L)	0	0.55	0.22	0.20
Cyanide (mg/L)	0	0.35	0.17	0.14

(C:\LOTUS\2213\GP-APC08.WK1)

TABLE C9 – (PREVIOUS RESULTS) INLET SEPARATOR SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA		
	SAMPLE #1	SAMPLE #2	SAMPLE #3
Carbonates (ppm)		630	
Corrosion Products (%)		66	63.4
Aluminum (ppm)	28		
Cobalt (ppm)	1		
Copper (ppm)	710	108	15000
Iron (ppm)	370000		
Manganese (ppm)	3240		
Molybdenum (ppm)	121		
Nickel (ppm)	300		
Thallium (ppm)	1		
Vanadium (ppm)	94.1		
Zinc (ppm)	34	18.8	
Organics and Volatile (ppm)		7330	
Paraffin Waxes (ppm)		3000	
Asphaltenes (%)		0.1	
Cadmium (mg/L)	3	11.3	
Chromium (mg/L)	130		
Lead (mg/L)	23		
Mercury (ug/L)	0.33		

(C:\LOTUS\2213\GP-APC09.WK1)

TABLE C9 – (PREVIOUS RESULTS) INLET SEPARATOR SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Carbonates (ppm)	630.00	630	630	0.00
Corrosion Products (%)	64.70	63.4	66	1.30
Aluminum (ppm)	28.00	28	28	0.00
Cobalt (ppm)	1.00	1	1	0.00
Copper (ppm)	5272.67	108	15000	6882.65
Iron (ppm)	370000.00	370000	370000	0.00
Manganese (ppm)	3240.00	3240	3240	0.00
Molybdenum (ppm)	121.00	121	121	0.00
Nickel (ppm)	300.00	300	300	0.00
Thallium (ppm)	1.00	1	1	0.00
Vanadium (ppm)	94.10	94.1	94.1	0.00
Zinc (ppm)	26.40	18.8	34	7.60
Organics and Volatile (ppm)	7330.00	7330	7330	0.00
Paraffin Waxes (ppm)	3000.00	3000	3000	0.00
Asphaltenes (%)	0.10	0.1	0.1	0.00
Cadmium (mg/L)	7.15	3	11.3	4.15
Chromium (mg/L)	130.00	130	130	0.00
Lead (mg/L)	23.00	23	23	0.00
Mercury (ug/L)	0.33	0.33	0.33	0.00

(C:\LOTUS\2213\GP-APC09.WK1)

TABLE C10 – (PREVIOUS RESULTS) LIME SLUDGE

PARAMETER	SAMPLE #1
Carbonates (%)	20.3
Copper (ppm)	0.01
Manganese (ppm)	0.15
Nickel (ppm)	0.075
Silver (ppm)	0.022
Zinc (ppm)	0.01
Arsenic (mg/L)	0.01
Barium (mg/L)	0.22
Boron (mg/L)	0.1
Cadmium (mg/L)	0.0002
Chromium (mg/L)	0.036
Lead (mg/L)	0.001
Mercury (ug/L)	0.00005
Selenium (mg/L)	0.5

(C:\LOTUS\231\SP-APC10.WK1)

TABLE C11 – (PREVIOUS RESULTS) NEUTRALIZED SULPHUR POND SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA				
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5
Cobalt (ppm)	43.5	13	0.08	1.4	
Copper (ppm)	21.8	14	0.04	1.27	
Iron (ppm)	34200	12900	113	3073	
Manganese (ppm)	650	150	3.59	75.1	
Molybdenum (ppm)	13.7	4	0.13	1.07	
Nickel (ppm)	41.5		0.24	3.57	
Silver (ppm)		1.4	0.02	0.02	
Vanadium (ppm)	31.8	12	0.1	2.16	
Zinc (ppm)	155	57	0.65	13.7	
Total Hydrocarbons (%)		2.99			
Iron Hydroxide (ppm)					17.4
Calcium Sulphate (ppm)					13.15
Calcium Chloride (ppm)					15.5
Magnesium Sulphate (ppm)					2.8
Manganese Oxide (ppm)					0.25
Zinc Oxide (ppm)					0.1
Silica (ppm)					2.75
Aluminium Oxide (ppm)					0.25
Alumium Sulphate (ppm)					34.4
Sodium Chloride (ppm)					0.2
Potassium (ppm)					0.05
Organic and Volatile (ppm)					13.2
Barium (mg/L)	23.7	51			
Boron (mg/L)		13			
Cadmium (mg/L)	0.4	1	0.02	0.26	
Chromium (mg/L)	26.4	14	0.1	1.85	
Lead (mg/L)	2	28	0.05	0.05	
Mercury (ug/L)	94	0.05			

(C:\LOTUS\ZIS&P-APC11.WK1)

TABLE C11 – (PREVIOUS RESULTS) NEUTRALIZED SULPHUR POND SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Cobalt (ppm)	14.50	0.08	43.5	17.48
Copper (ppm)	9.28	0.04	21.8	9.06
Iron (ppm)	12571.50	113	34200	13354.17
Manganese (ppm)	219.67	3.59	650	253.79
Molybdenum (ppm)	4.73	0.13	13.7	5.37
Nickel (ppm)	15.10	0.24	41.5	18.71
Silver (ppm)	0.48	0.02	1.4	0.65
Vanadium (ppm)	11.52	0.1	31.8	12.55
Zinc (ppm)	56.59	0.65	155	60.53
Total Hydrocarbons (%)	1.495	0	2.99	1.50
Iron Hydroxide (ppm)	8.7	0	17.4	8.70
Calcium Sulphate (ppm)	13.15	13.15	13.15	0.00
Calcium Chloride (ppm)	15.5	15.5	15.5	0.00
Magnesium Sulphate (ppm)	1.4	0	2.8	1.40
Manganese Oxide (ppm)	0.25	0.25	0.25	0.00
Zinc Oxide (ppm)	0.1	0.1	0.1	0.00
Silica (ppm)	2.75	2.75	2.75	0.00
Aluminium Oxide (ppm)	0.25	0.25	0.25	0.00
Alumium Sulphate (ppm)	17.2	0	34.4	17.20
Sodium Chloride (ppm)	0.2	0.2	0.2	0.00
Potassium (ppm)	0.05	0.05	0.05	0.00
Organic and Volatile (ppm)	6.6	0	13.2	6.60
Barium (mg/L)				
Boron (mg/L)				
Cadmium (mg/L)	0.42	0.02	1	0.36
Chromium (mg/L)	10.5875	0.1	26.4	10.58
Lead (mg/L)	7.525	0.05	28	11.85
Mercury (ug/L)	47.025	0.05	94	46.98

(C:\LOTUS\E13&P-APC11.WK1)

TABLE C12 – (PREVIOUS RESULTS) PROCESS POND SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA				
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5
Ammonia (ppm)			50		
Hydrogen Sulfide (ppm)					
Aluminum (ppm)			12400	15500	
Chromium (+6) (ppm)	0.06	0.06		1056	
Cobalt (ppm)	25	27	4.2		17
Copper (ppm)	122	133	36		18
Iron (ppm)	83000	91000	11000		15500
Manganese (ppm)	221	237	370		120
Molybdenum (ppm)	194	210	1.1		4.2
Nickel (ppm)	1050	1108	14	26.5	36
Silver (ppm)					1.6
Thallium (ppm)			49		
Vanadium (ppm)	42	43	25		14
Zinc (ppm)	240	237	170		97
Total Hydrocarbons (%)				2.35	
Total Phenol (ppm)	3.1	5.2	0.33	0.2	
BTEX (ppm)				340	
PAH's (ppm)				14500	
Paraffins/Olefins (ppm)				11500	
Organosulphur Comp (ppm)				20.2	
Naphthalene (ppm)					
Arsenic (mg/L)	15	14	3.9	0.15	
Barium (mg/L)	192	110	170		86
Boron (mg/L)	8	6	5.2		18
Cadmium (mg/L)	1.4	1.3	0.58	4.3	< 1
Chromium (mg/L)	495	689	18		15
Lead (mg/L)	26	23	17	5.5	34
Mercury (ug/L)	0.0076	0.0044	0.17	0.315	0.057
Selenium (mg/L)					
Cyanide (mg/L)	0.1	0.1	14	0.17	

(C:\LOTUS\2213\GP-APC12.WK1)

TABLE C12 – (PREVIOUS RESULTS) PROCESS POND SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #6	SAMPLE #7	SAMPLE #8	SAMPLE #9
Ammonia (ppm)			274	
Hydrogen Sulfide (ppm)				5000
Aluminum (ppm)			15800	
Chromium (+6) (ppm)	0.07	0.07		
Cobalt (ppm)			7.8	
Copper (ppm)	120	125	43.6	
Iron (ppm)			15200	
Manganese (ppm)	370	215	519	
Molybdenum (ppm)	53	13	2.08	
Nickel (ppm)	15	25	19.3	
Silver (ppm)				
Thallium (ppm)			7.56	
Vanadium (ppm)			40.8	
Zinc (ppm)			192	
Total Hydrocarbons (%)				0.8
Total Phenol (ppm)	0.2	0.1	9.6	
BTEX (ppm)				
PAH's (ppm)		1020		9.5
Paraffins/Olefins (ppm)		19000		
Organosulphur Comp (ppm)				27
Naphthalene (ppm)		50		
Arsenic (mg/L)	0.046	7	2.93	0.0015
Barium (mg/L)	73	72	249	
Boron (mg/L)	700	18	9.64	
Cadmium (mg/L)	6	4	0.49	0.001
Chromium (mg/L)	5100	3250	190	
Lead (mg/L)	<5	<5	11	
Mercury (ug/L)	0.8	1	0.065	0.21
Selenium (mg/L)	<0.00015	<0.00015		0.0005
Cyanide (mg/L)	0.19	0.11	5.42	

(C:\LOTUS\2213\S\P-APC12.WK1)

TABLE C12 – (PREVIOUS RESULTS) PROCESS POND SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Ammonia (ppm)	162.00	50	274	112.00
Hydrogen Sulfide (ppm)	5000.00	5000	5000	0.00
Aluminum (ppm)	14566.67	12400	15800	1536.95
Chromium (+6) (ppm)	211.25	0.06	1056	422.37
Cobalt (ppm)	16.20	4.2	27	9.05
Copper (ppm)	85.37	18	133	46.45
Iron (ppm)	43140.00	11000	91000	35936.03
Manganese (ppm)	293.14	120	519	123.79
Molybdenum (ppm)	68.20	1.1	210	86.34
Nickel (ppm)	286.73	14	1108	457.70
Silver (ppm)	1.60	1.6	1.6	0.00
Thallium (ppm)	28.28	7.56	49	20.72
Vanadium (ppm)	32.96	14	43	11.55
Zinc (ppm)	187.20	97	240	52.39
Total Hydrocarbons (%)	1.58	0.8	2.35	0.77
Total Phenol (ppm)	2.68	0.1	9.6	3.36
BTEX (ppm)	340.00	340	340	0.00
PAH's (ppm)	5176.50	9.5	14500	6605.60
Paraffins/Olefins (ppm)	15250.00	11500	19000	3750.00
Organosulphur Comp (ppm)	23.60	20.2	27	3.40
Naphthalene (ppm)	50.00	50	50	0.00
Arsenic (mg/L)	5.38	0.0015	15	5.73
Barium (mg/L)	136.00	72	249	63.59
Boron (mg/L)	109.26	5.2	700	241.22
Cadmium (mg/L)	2.01	0	6	2.07
Chromium (mg/L)	1393.86	15	5100	1841.16
Lead (mg/L)	14.56	0	34	11.75
Mercury (ug/L)	0.29	0.0044	1	0.34
Selenium (mg/L)	0.00	0	0.0005	0.00
Cyanide (mg/L)	2.87	0.1	14	4.90

(C:\LDTUB\2213\SP-APC12.WK1)

TABLE C13 – (PREVIOUS RESULTS) SULFINOL SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Ash Content (%)			8.7	1.3
TDS (ppm)			43300	23500
Carbon–Nitrogen Ratio	54.2			
Chromium (+6) (ppm)			3	0.2
Iron (ppm)			1020	721
Vanadium (ppm)			650	128
Organic Matter (%)	17.7			
Sulfinol (Sulfolane) (ppm)	125	3.57	350	7500
DIPA (ppm)		1.88	150	10800
DEA (ppm)	22			
DEG (ppm)	40			
BTEX (ppm)	2.29			
Naphthalene (ppm)	112			
Flourene (ppm)	43			
Phenanthrene (ppm)	44			
Nitrogen Degradation Products (%)		22.77		
Oxazolidone (%)		71.38		
Arsenic (mg/L)			0.04	0.03
Cadmium (mg/L)			7.8	1300
Lead (mg/L)			0.3	0.85
Mercury (ug/L)			0.009	0.009
Cyanide (mg/L)			14.5	0.009

TABLE C13 – (PREVIOUS RESULTS) SULFINOL SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Ash Content (%)	5.00	1.3	8.7	3.70
TDS (ppm)	33400.00	23500	43300	9900.00
Carbon–Nitrogen Ratio	54.20	54.2	54.2	0.00
Chromium (+6) (ppm)	1.60	0.2	3	1.40
Iron (ppm)	870.50	721	1020	149.50
Vanadium (ppm)	389.00	128	650	261.00
Organic Matter (%)	8.85	0	17.7	8.85
Sulfinol (Sulfolane) (ppm)	1994.64	3.57	7500	3180.95
DIPA (ppm)	3650.63	1.88	10800	5055.73
DEA (ppm)	22.00	22	22	0.00
DEG (ppm)	40.00	40	40	0.00
BTEX (ppm)	2.29	2.29	2.29	0.00
Naphthalene (ppm)	112.00	112	112	0.00
Flourene (ppm)	43.00	43	43	0.00
Phenanthrene (ppm)	44.00	44	44	0.00
Nitrogen Degradation Products (%)	22.77	22.77	22.77	0.00
Oxazolidone (%)	35.69	0	71.38	35.69
Arsenic (mg/L)	0.04	0.03	0.04	0.00
Cadmium (mg/L)	653.90	7.8	1300	646.10
Lead (mg/L)	0.58	0.3	0.85	0.28
Mercury (ug/L)	0.01	0.009	0.009	0.00
Cyanide (mg/L)	7.25	0.009	14.5	7.25

(C:\LDTU\B2213\G\P-APC13.WK1)

TABLE C14 – (PREVIOUS RESULTS) UN–NEUTRALIZED SULPHUR POND SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Ammonia (ppm)	28	29	33	58
Aluminum (ppm)	17000	15000	18000	16700
Cobalt (ppm)	2.3	2.2	2.3	4.04
Copper (ppm)	18	18	20	17.9
Iron (ppm)	6700	6000	6600	6750
Manganese (ppm)	46	45	49	52.5
Molybdenum (ppm)	0.4	1.1	1.7	1.59
Nickel (ppm)	9.5	8.2	7.7	8.56
Thallium (ppm)	49	49	49	4.53
Vanadium (ppm)	35	38	43	43
Zinc (ppm)	47	45	49	38.3
Total Phenol (ppm)	0.04	0.04	0.16	3.17
Arsenic (mg/L)	4.7	4.5	4.8	3.63
Barium (mg/L)	180	120	190	240
Boron (mg/L)	12	8.8	11	10.8
Cadmium (mg/L)	0.22	0.38	0.39	0.4
Chromium (mg/L)	67	66	61	43.7
Lead (mg/L)	12	14	15	8.56
Mercury (ug/L)	0.072	0.082	0.088	0.005
Selenium (mg/L)	0.02	0.011	0.025	0.65
Cyanide (mg/L)	18	17	17	2.81

(C:\LOTUS\3213\GP-APC14.WK1)

TABLE C14 – (PREVIOUS RESULTS) UN–NEUTRALIZED SULPHUR POND SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Ammonia (ppm)	37	28	58	12.268
Aluminum (ppm)	16675	15000	18000	1080.220
Cobalt (ppm)	2.71	2.2	4.04	0.769
Copper (ppm)	18.475	17.9	20	0.881
Iron (ppm)	6512.5	6000	6750	300.780
Manganese (ppm)	48.125	45	52.5	2.924
Molybdenum (ppm)	1.1975	0.4	1.7	0.513
Nickel (ppm)	8.49	7.7	9.5	0.658
Thallium (ppm)	37.8825	4.53	49	19.256
Vanadium (ppm)	39.75	35	43	3.419
Zinc (ppm)	44.825	38.3	49	4.024
Total Phenol (ppm)	0.8525	0.04	3.17	1.339
Arsenic (mg/L)	4.4075	3.63	4.8	0.462
Barium (mg/L)	182.5	120	240	42.647
Boron (mg/L)	10.65	8.8	12	1.161
Cadmium (mg/L)	0.3475	0.22	0.4	0.074
Chromium (mg/L)	59.425	43.7	67	9.359
Lead (mg/L)	12.39	8.56	15	2.461
Mercury (ug/L)	0.06175	0.005	0.088	0.033
Selenium (mg/L)	0.1765	0.011	0.65	0.273
Cyanide (mg/L)	13.7025	2.81	18	6.302

(C:\LOTUS\[illegible]\APC14.WK1)

TABLE C15 – (PREVIOUS RESULTS) WATER TREATMENT SLUDGE

PARAMETER	RESULTS FROM PREVIOUS DATA			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4
Total Sulphur (%)				
TDS (ppm)		26500	30700	44800
Aluminum (ppm)		1620	1800	2350
Cobalt (ppm)	14			
Copper (ppm)	19			
Iron (ppm)	14200	185	26	610
Manganese (ppm)	65			
Molybdenum (ppm)	4.9			
Nickel (ppm)	30			
Silver (ppm)	1.3			
Vanadium (ppm)	13			
Zinc (ppm)	90			
Total Hydrocarbons (%)	2.57			
Barium (mg/L)	80			
Boron (mg/L)	187			
Cadmium (mg/L)	0.09			
Chromium (mg/L)	16			
Lead (mg/L)	33			
Mercury (ug/L)	74			

(C:\LOTUS\23\3&P-APC15.WK1)

TABLE C15 – (PREVIOUS RESULTS) WATER TREATMENT SLUDGE

PARAMETER	STATISTICAL PARAMETERS			
	MEAN	MIN	MAX	STD. DEV.
Total Sulphur (%)	0.00	0	0	0.00
TDS (ppm)	34000.00	26500	44800	7826.88
Aluminum (ppm)	1923.33	1620	2350	310.52
Cobalt (ppm)	14.00	14	14	0.00
Copper (ppm)	19.00	19	19	0.00
Iron (ppm)	3755.25	26	14200	6034.06
Manganese (ppm)	65.00	65	65	0.00
Molybdenum (ppm)	4.90	4.9	4.9	0.00
Nickel (ppm)	30.00	30	30	0.00
Silver (ppm)	1.30	1.3	1.3	0.00
Vanadium (ppm)	13.00	13	13	0.00
Zinc (ppm)	90.00	90	90	0.00
Total Hydrocarbons (%)	1.29	0	2.57	1.28
Barium (mg/L)	80.00	80	80	0.00
Boron (mg/L)	187.00	187	187	0.00
Cadmium (mg/L)	0.09	0.09	0.09	0.00
Chromium (mg/L)	16.00	16	16	0.00
Lead (mg/L)	33.00	33	33	0.00
Mercury (ug/L)	74.00	74	74	0.00

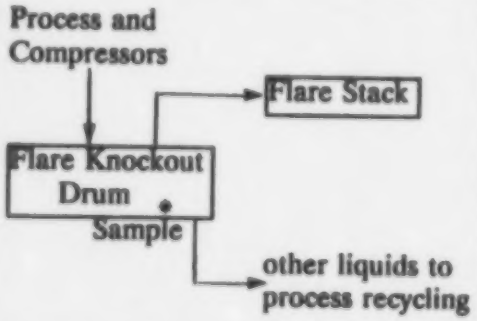
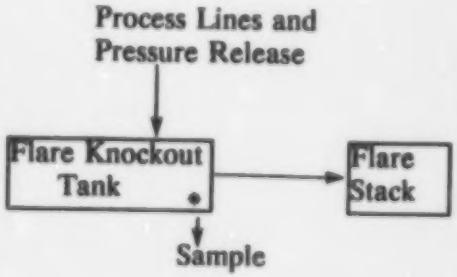
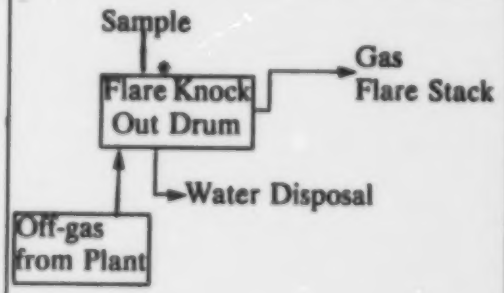
(C:\LOTUS\2213\3\P-APC15.WK1)

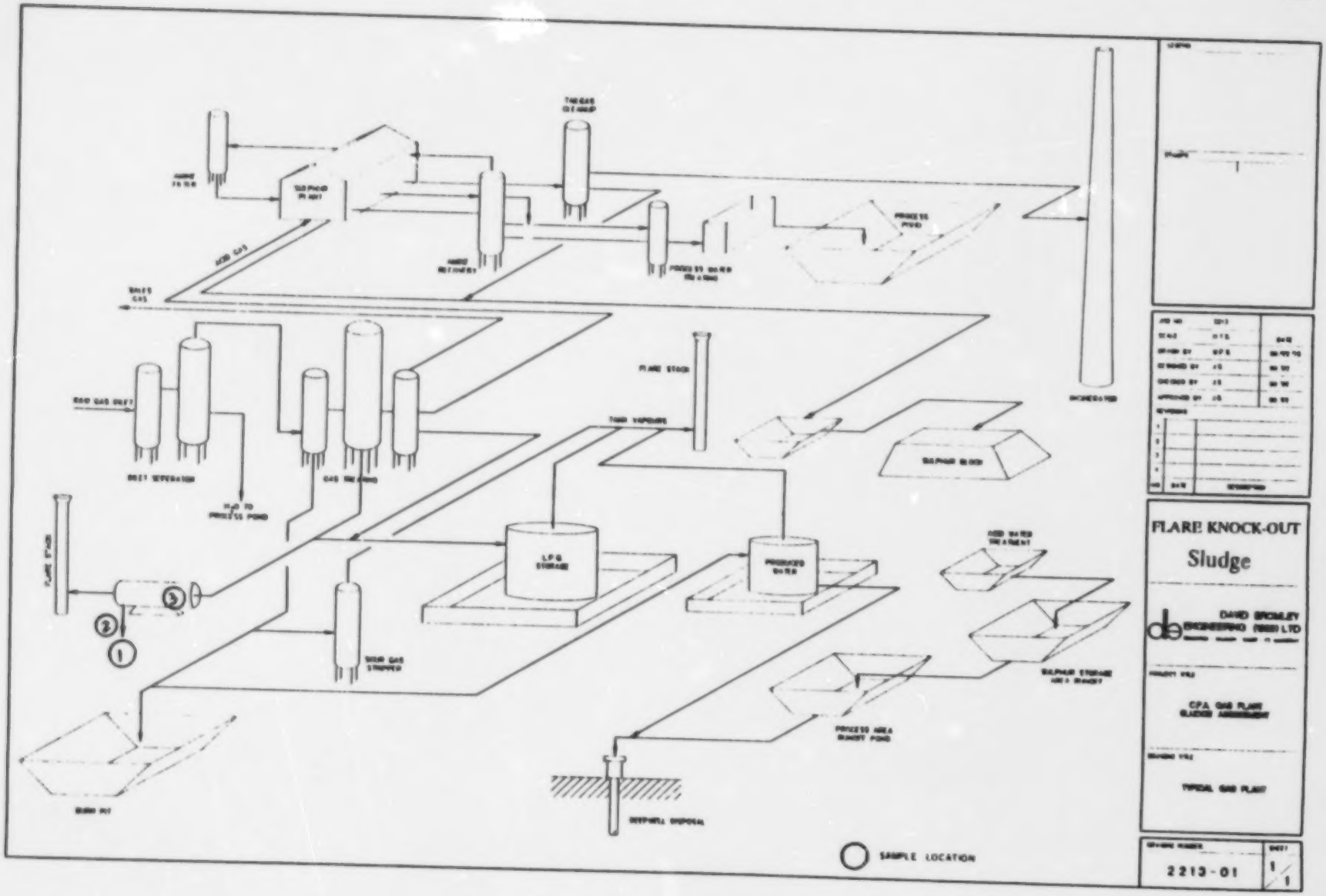
APPENDIX D

SAMPLING REPORTS

FLARE KNOCK-OUT SLUDGE
Identification Number: 1

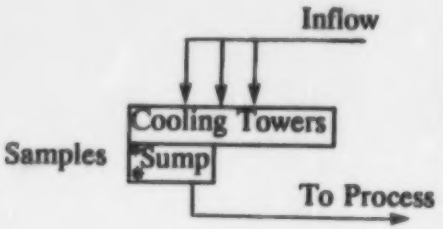
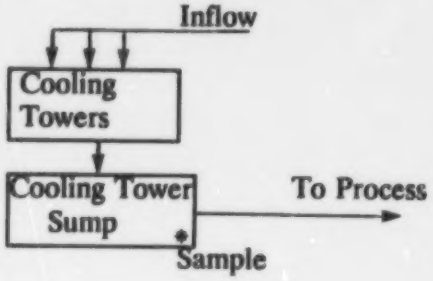
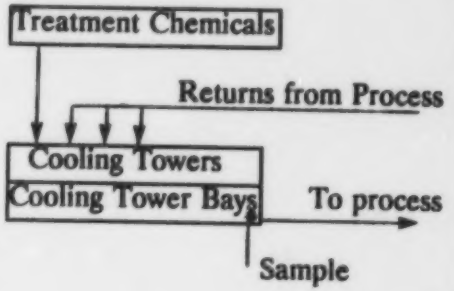
CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

Sample # / Plant Specifics	1 Constructed in 1964. Straddle Plant.	2 Sour-Sulphur Recovery – 23 t/d using DEA Amine, S-block is present. Constructed in 1972, capacity is 90,000 m3/d dry.	3
Composite of	1 Sample	1 Sample	1 Sample
Date Sampled	2 March 1990	1 March 1990	Early January 1990
Analysis Began	6 February 1990	6 March 1990	6 April 1990
Analysis Complete	17 February 1990	28 March 1990	23 April 1990
Sample Location	Flare knockout drum at base of flare stack at northwestern side of plant.	Flare knockout drum on east side of plant next to flare pit.	Flare knockout drum buried 2 m deep in the ground. Access via manhole.
Sampling Technique	Drain valve at bottom of tank used to obtain sample. Sample transferred directly into sample container.	A drain valve at the bottom of the drum allowed us to draw a sample directly into the sample container.	Grab sample taken through the manhole with a plastic cup.
Visual Description	Fairly clear and watery. Very little sludge. High methanol content.	Black and oily with a treacle-like consistency.	Light brown with a bit of granular sediment. Consists mainly of oil, gas and produced water.
Sample Source Diagram			


FLARE KNOCK-OUT
Sludge
DAVID BROMLEY ENGINEERING (1988) LTD
CPA GAS FLARE
TYPICAL GAS FLARE
2213-01
1
1
SAMPLE LOCATION

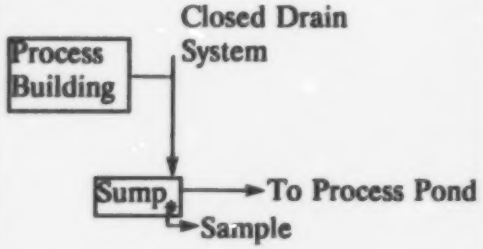
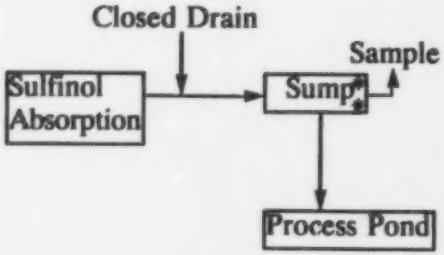
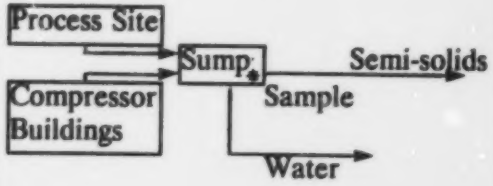
COOLING TOWER SLUDGE
Identification Number: 2

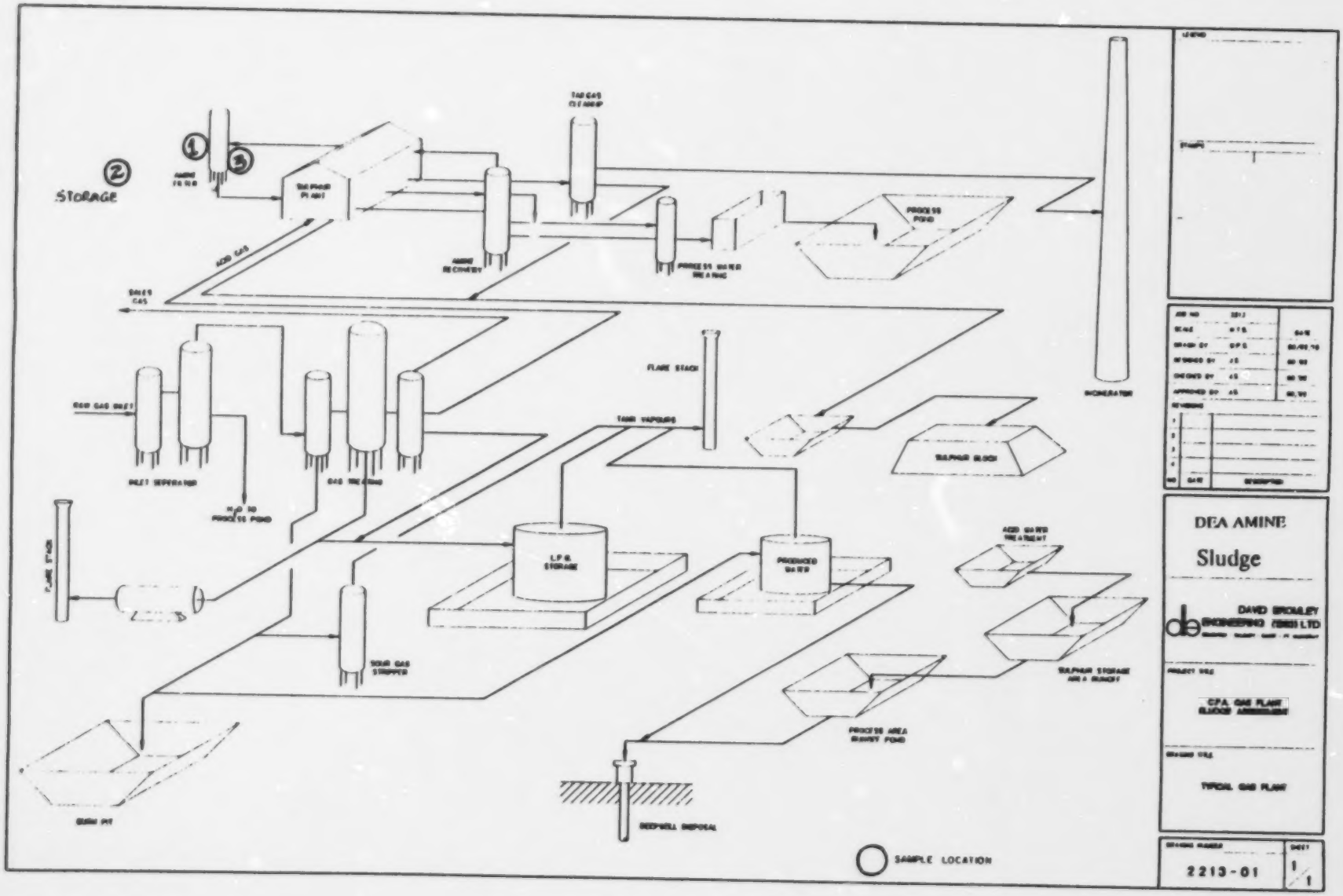
CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

Sample # / Plant Specifics	1	2 Sweet, constructed in 1969. Straddle plant.	3 Sour–Sulphur Recovery– 800 t/d using Sulfinol, S–block present. Constructed in 1952, capacity is 6,000,000 m3/d dry.
Composite of	2 Samples	1 Sample	1 Sample
Date Sampled	12 January 1990	23 January 1990	23 January 1990
Analysis Began	6 February 1990	6 February 1990	6 February 1990
Analysis Complete	17 February 1990	17 February 1990	17 February 1990
Sample Location	Concrete bay at base of cooling towers. Concrete sump is 7m deep.	Cooling tower vault about 3 m deep.	Cooling tower bay about 2 m deep.
Sampling Technique	Grab sample taken from bottom of sump using a vacuum apparatus. Pails were filled with sludge and allowed to settle. The fluid was decanted; the sludge was put into glass bottles.	Grab sample taken from bottom of vault using vacuum apparatus. Sludge was placed in glass bottle.	Sample collected using a long handled scoop which provided access to corners of sump where sludge accumulates. The sludge was then poured into a glass bottle
Visual Description	Fairly fine texture, grey to black color, viscous.	Grey to black color, high solids content.	Grey, brown color, high liquid content.
Sample Source Diagram			

PROCESS FLOOR DRAIN SLUDGE
Identification Number: 3

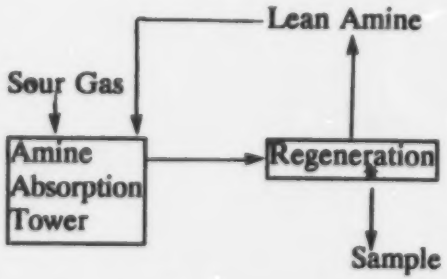
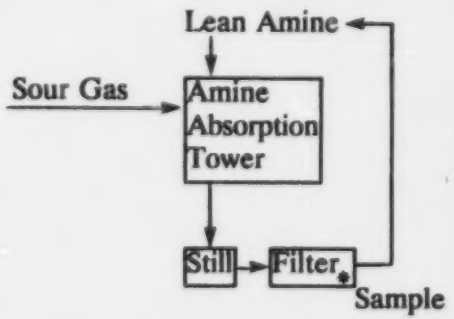
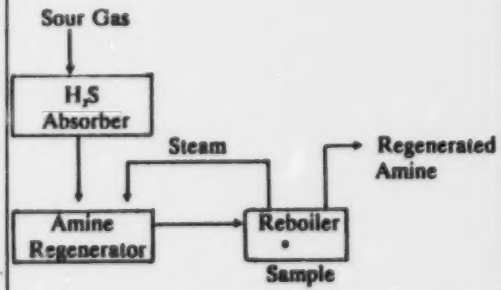
CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

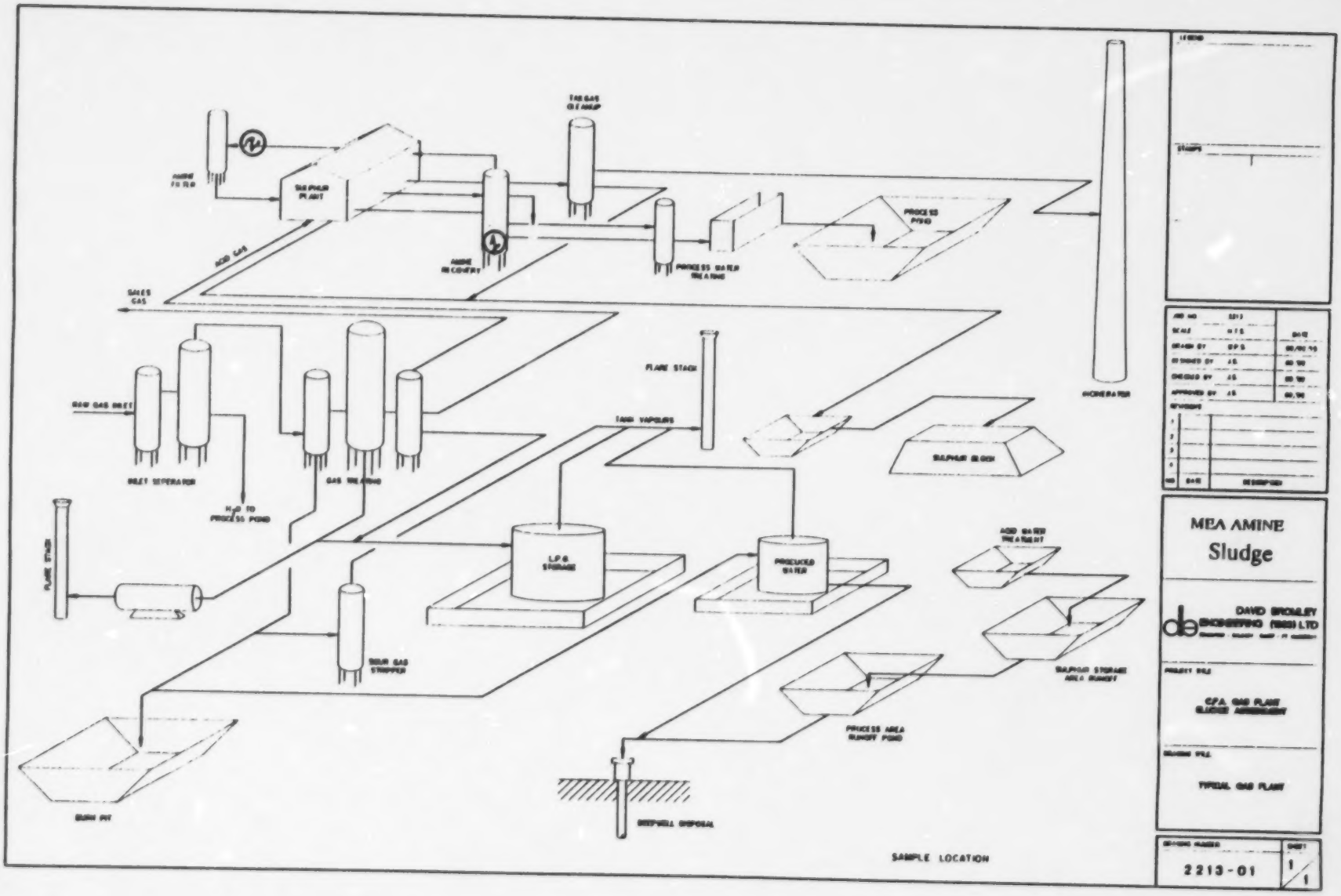
Sample # Plant Specifics	1 Sour-Sulphur Recovery – 28 t/d using DEA Amine, no S-block present. Constructed in 1961, capacity is 2,800,000 m3/d dry.	2 Sour-Sulphur Recovery – 800 t/d using Sulfinol, S-block is present. Constructed in 1952, capacity is 6,000,000 m3/d dry.	3 Sour-Sulphur Recovery – 800 t/d using Sulfinol, S-block is present. Constructed in 1967, capacity is 6,000,000 m3/d dry.
Composite of	3 samples	1 Sample	1 Sample
Date Sampled	7 November 1989	14 December 1989	22 December 1989
Analysis Began	9 February 1990	9 February 1990	6 February 1990
Analysis Complete	26 February 1990	26 February 1990	17 February 1990
Sample Location	3.0 m sump in sour gas plant process area.	Sewer catch basin inside of process building in a sour gas plant.	Process floor drains into a vault outside the process building, which pumps liquids to salt water tank, and disposal well.
Sampling Technique	Vacuum pump used to obtain samples from sump bottom with access via a manhole. 3 – 1 litre samples were taken and combined into a composite sample. A 500 ml sample was then transferred into a glass bottle.	Grab sample taken with plastic beaker by scraping up sludge from catch basin just below water surface. Sample transferred from beaker to glass sample bottle.	During the period that the water was pumped out of the vault a grab sample was taken using a shovel and transferred to a glass bottle.
Visual Description	Very black and oily. The water in the sump was brown with a film of oil on its surface.	Yellow-brown in colour with a high fluid content.	Black fluid, slightly oily with a strong odour.
Sample Source Diagram			


STORAGE
FLARE STACK
INCINERATOR
LPG STORAGE
PRODUCED WATER
SULPHUR BLOCK
PROCESS POND
SOUR GAS STRIPPER
DEEPWELL DISPOSAL
SAMPLE LOCATION
DEA AMINE
Sludge
DAVID BROMLEY ENGINEERING (1983) LTD
CPA GAS PLANT
TYPICAL GAS PLANT
2213-01

MEA AMINE SLUDGE
Identification Number: 5

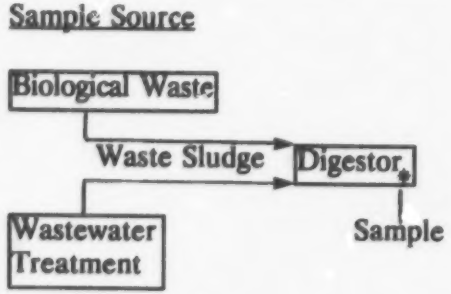
CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

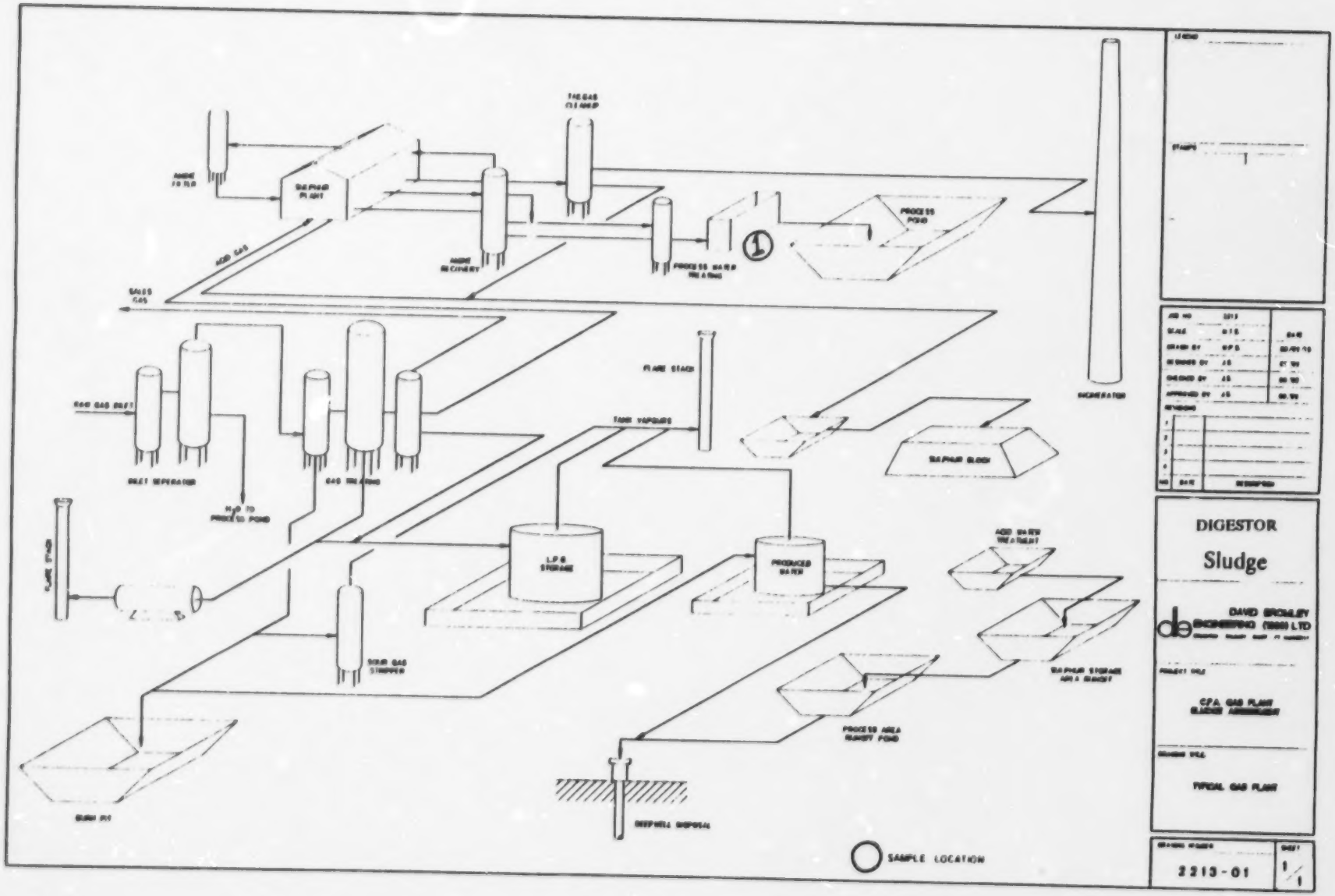
Sample # Plant Specifics	1 Sour–Sulphur Recovery – 50 t/d using MEA Amine, no S–block is present. Constructed in 1960, capacity is 6,000,000 m3/d dry.	2 Sour–Sulphur Recovery – 6 t/d using MEA Amine, no S–block is present. Constructed in 1954, capacity is 100,000 m3/d dry.	3 Sour – No Sulphur Recovery – MEA Amine Sweetening. Constructed in 1963, capacity is 3,350,000 m3/d dry.
Composite of	1 Sample	1 Sample	1 Sample
Date Sampled	22 May 1990	22 May 1990	14 June 1990
Analysis Began			
Analysis Complete	4 September 1990	4 September 1990	4 September 1990
Sample Location	Amine absorption tower.	Amine filter unit.	Amine reboiler
Sampling Technique	The sample was obtained from the floor of the contactor tower using a plastic scoop. The plant was shut down at the time.	Sample was extracted from the filter unit through a drain valve.	Sample obtained by plant operator from dump valve on the reboiler.
Visual Description	Thick greenish–black sludge.	Greenish color with a small amount of dark colored solids.	Thick black sludge with a fine consistency.
Sample Source Diagram			


SULPHUR PLANT
ACID GAS
SALES GAS
AMINE RECOVERY
PROCESS POND
PROCESS WATER TREATING
INCINERATOR
FLARE STACK
SULPHUR BLOCK
GAS WASHING
LPG STORAGE
PRODUCED WATER
ACID WATER TREATMENT
PROCESS AREA RUNOFF POND
SAMPLE LOCATION
MEA AMINE
Sludge
DAVID BROMLEY
CFA GAS PLANT
TYPICAL GAS PLANT
2213-01

DIGESTOR SLUDGE
Identification Number: 6

CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

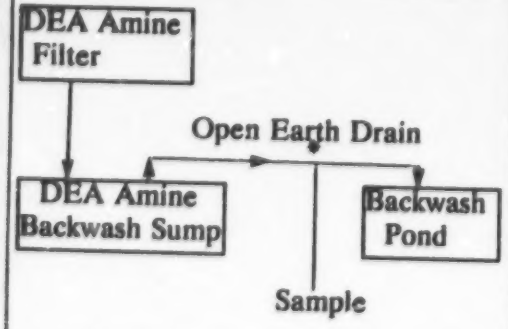
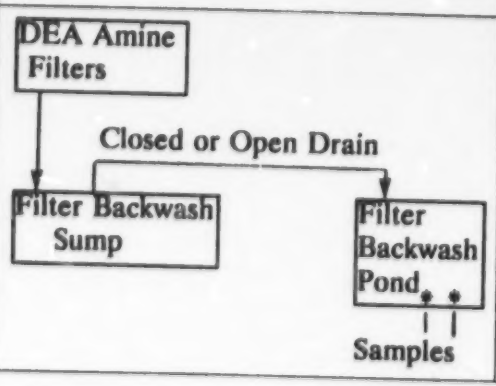
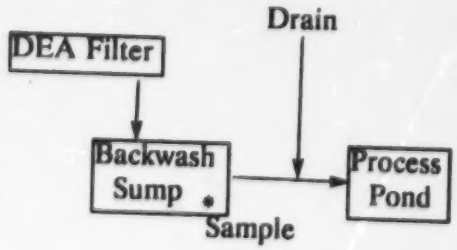
Sample # / Plant Specifics	1 Sour-Sulphur Recovery - 2400 t/d using DIPA Amine and Sulfinol, S-block is present. Constructed in 1962, capacity is 8,875,000 m3/d dry.	2	3
Composite of	1 Sample		
Date Sampled	7 December 1989		
Analysis Began	9 February 1990		
Analysis Complete	26 February 1990		
Sample Location	Digestor		
Sampling Technique	Sample taken from the recycle flow line.		
Visual Description	Brown		
Sample Source Diagram			

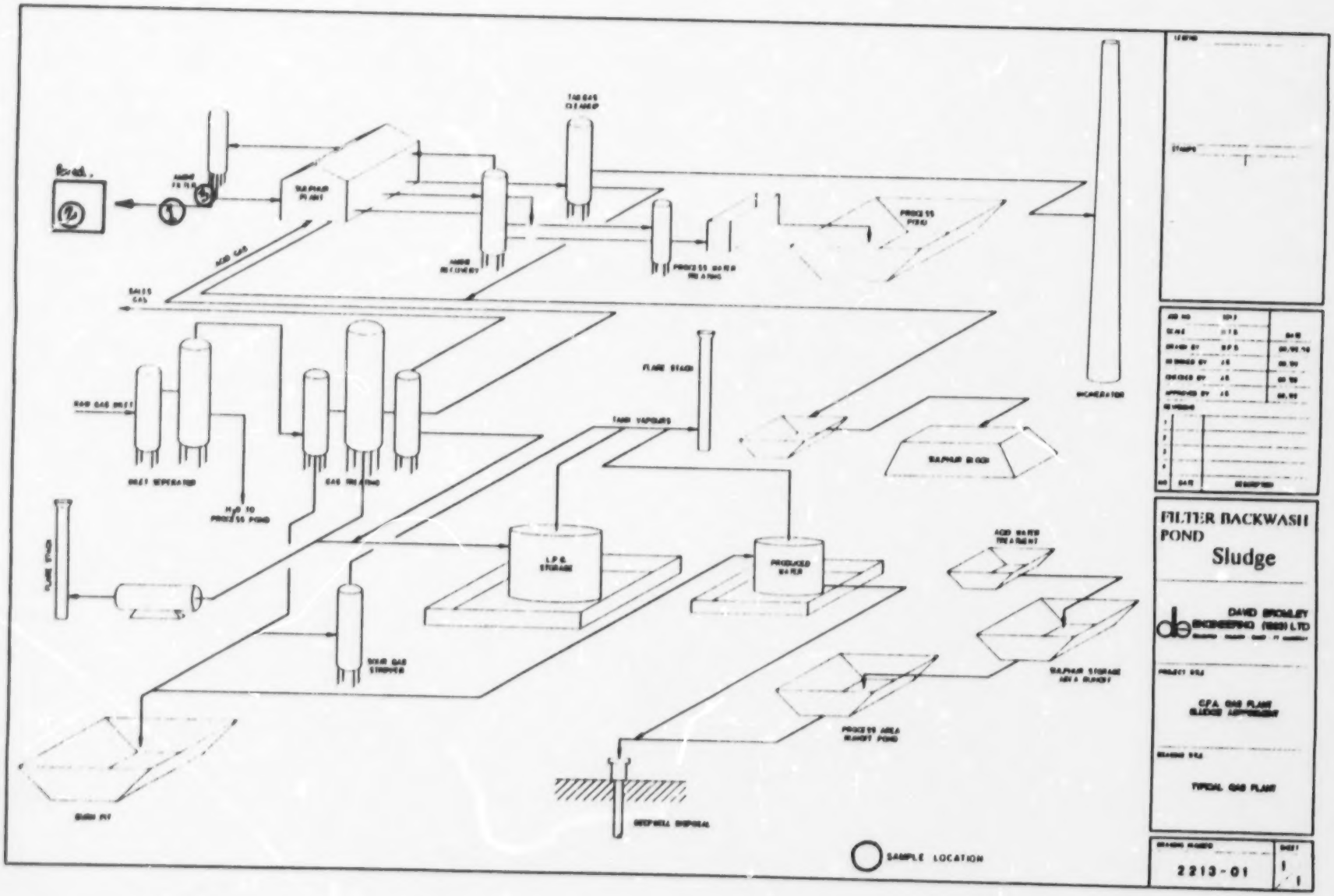

SALES GAS
FLARE STACK
TANK VAPOURS
INCINERATOR
SULPHUR BLOCK
INLET SEPARATOR
GAS TREATING
LPG STORAGE
PRODUCED WATER
SOUR GAS STRIPPER
SULPHUR STORAGE
PROCESS AREA RUNOFF POND
DEEPWELL DISPOSAL
SAMPLE LOCATION
DIGESTOR
Sludge
DAVID BROMLEY ENGINEERING (1988) LTD
CPA GAS PLANT
TYPICAL GAS PLANT
2213-01
1/1

FILTER BACKWASH POND SLUDGE
Identification Number: 7

CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY

SAMPLING REPORT

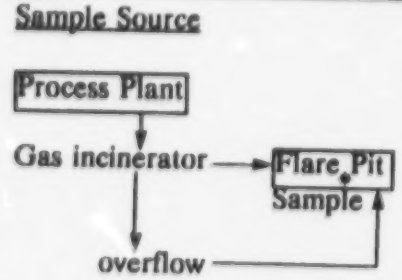
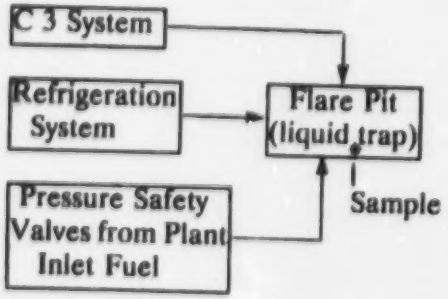
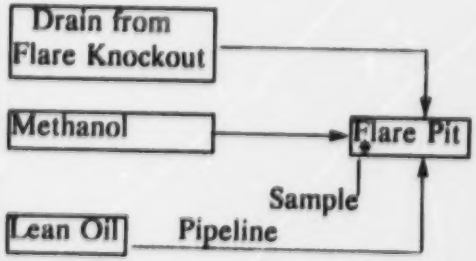
Sample # / Plant Specifics	1 Sour-Sulphur Recovery – 850 t/d using DEA Amine, no S-block present. Constructed in 1962, capacity is 4,000,000 m3/d dry.	2 Sour-Sulphur Recovery – 2400 t/d using DEA Amine, S-block is present. Constructed in 1971, capacity is 12,000,000 m3/d dry.	3 Sour-Sulphur Recovery – 800 t/d using Sulfinol, S-block is present. Constructed in 1952, capacity is 6,000,000 m3/d dry.
Composite of	1 Sample	2 Samples	1 Sample
Date Sampled	14 December 1989	9 January 1990	10 January 1990
Analysis Began	9 February 1990	6 February 1990	6 February 1990
Analysis Complete	26 February 1990	17 February 1990	17 February 1990
Sample Location	Sample taken from open ditch routing DEA diatomaceous earth filter backwash from the filters to the filter backwash pond.	Sample taken from filter backwash pond sludge storage pad.	Sample taken from the filter backwash vault outside the building housing the DEA Amine filter.
Sampling Technique	A single 500 ml glass sample bottle was filled.	Samples were taken from different points on the sludge storage pad and put directly into sample bottles.	A sample was taken by forcing a long hollow fibreglass pole into the sludge at the bottom of the vault. The sludge was scraped from the tube into glass bottles.
Visual Description	Sample was yellow-brown to dark brown in color and had a strong offensive odour.	Sample has a brownish appearance and was dry.	Black with a strong odour and semi-solid. Appeared to consist mainly of cellulose and diatomacous earth.
Sample Source Diagram			

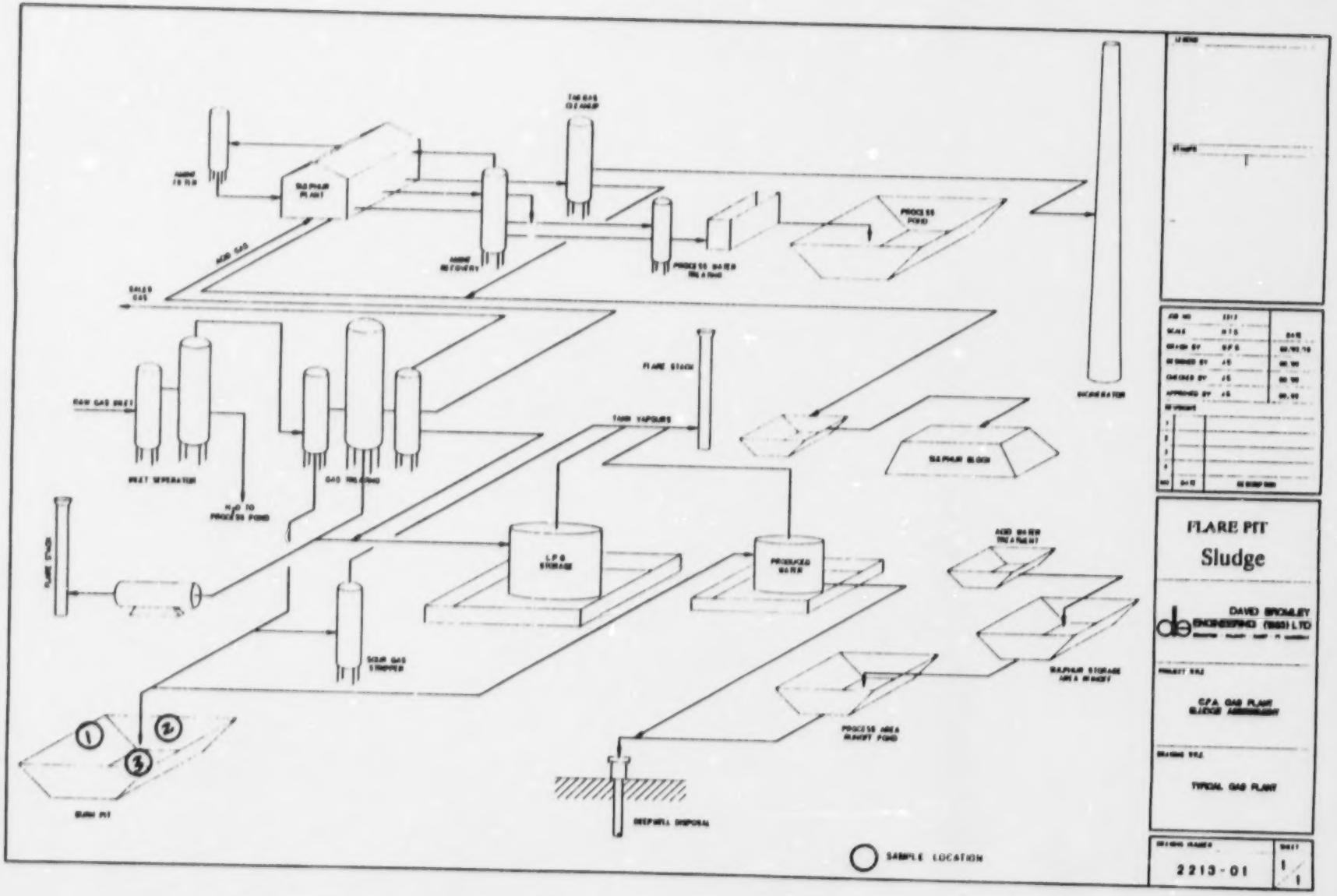

FLARE STACK
SULPHUR BLOCK
L.P.G. STORAGE
PRODUCED WATER
SAMPLE LOCATION
FILTER BACKWASH POND
Sludge
DAVID BROMLEY ENGINEERING (1989) LTD
CFA GAS PLANT
TYPICAL GAS PLANT
2213-01

FLARE PIT SLUDGE
Identification Number: 8

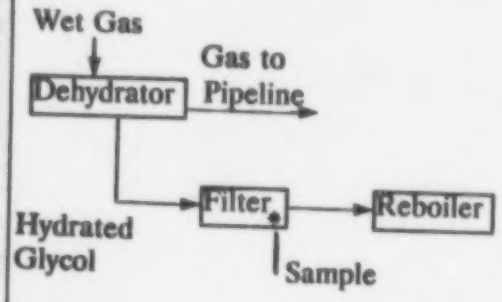
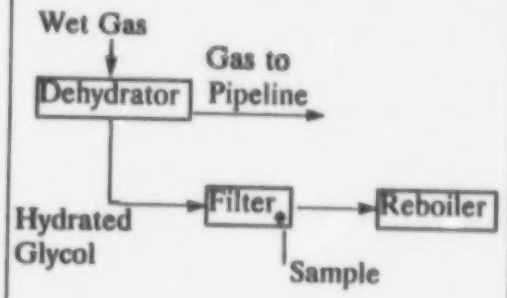
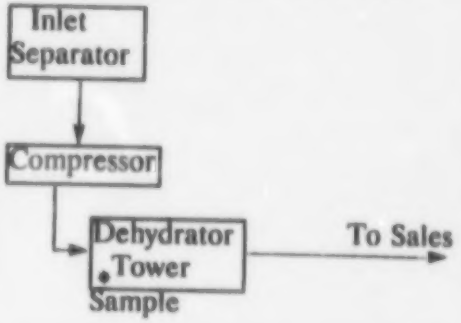
CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY

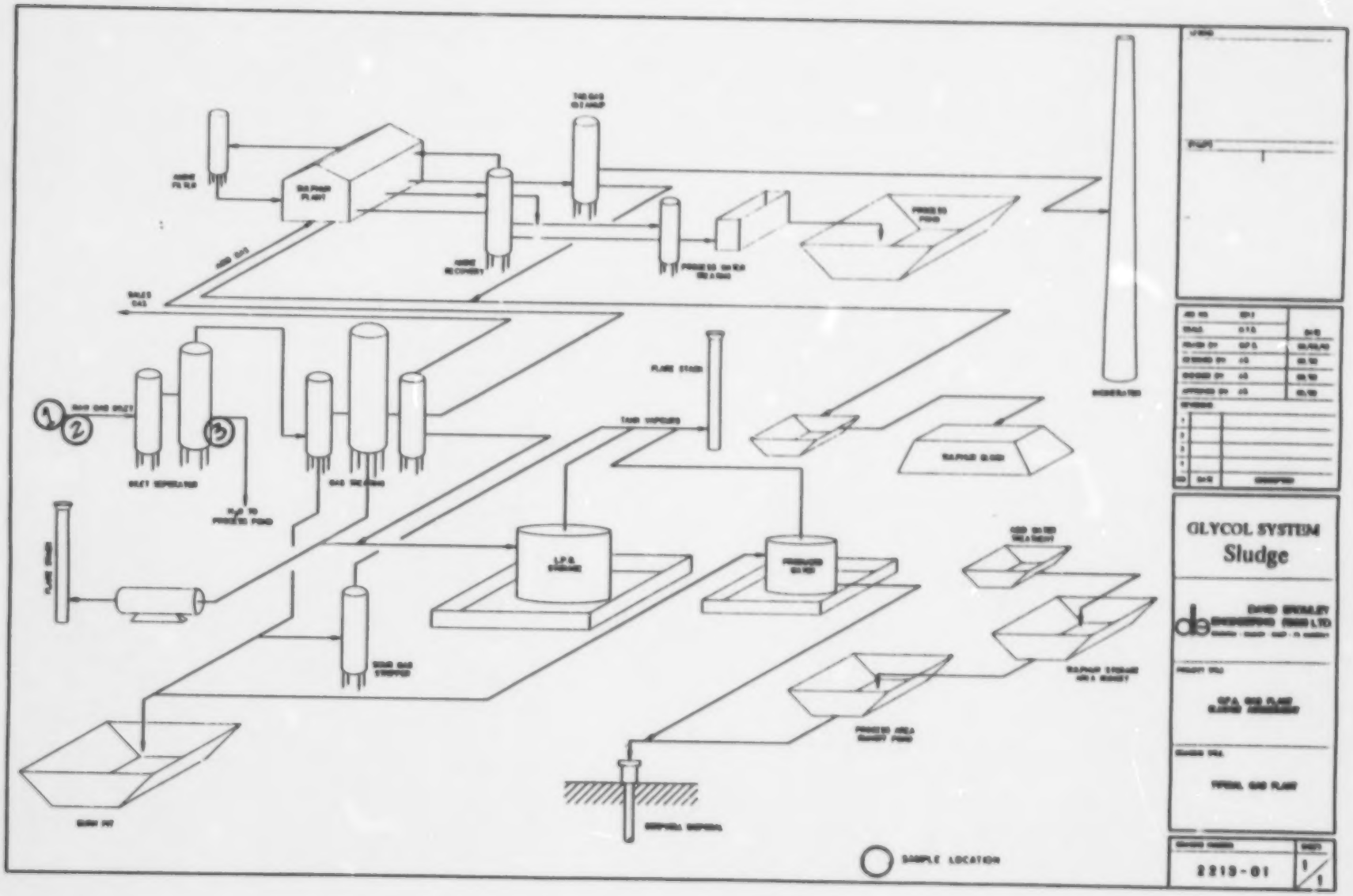
SAMPLING REPORT

Sample # Plant Specifics	1 Sour-Gas Flare – 5 t/d using DEA Amine and Sulfinol, no S-block present. Constructed in 1967, capacity is 1,226,000 m3/d dry.	2 Sour-Sulphur Recovery – 23 t/d using DEA Amine, S-block is present. Constructed in 1972, capacity is 90,000 m3/d dry.	3 Constructed in 1964. Straddle plant.
Composite of	1 Sample	1 Sample	1 Sample
Date Sampled	7 December 1989	1 March 1990	2 March 1990
Analysis Began	9 February 1990	6 February 1990	6 April 1990
Analysis Complete	26 February 1990	17 February 1990	23 April 1990
Sample Location	Flare pit.	Flare pit next to flare stack.	Flare pit adjacent to flare knockout tank and flare stack.
Sampling Technique	Sludge was removed from the flare pit. A composite sample was made and placed in a glass sample bottle.	A long handled shovel was used to collect the sample.	A long handled shovel was used to scoop up a sample from the flare pit.
Visual Description	Black, oily and frozen. Hydrocarbon contaminated soil was present in the flare pit.	Soil highly contaminated with hydro-carbons and black in color. The ground was moist.	Dark colored soil (impregnated with hydrocarbons). Sample was very dry.
Sample Source Diagram			


FLARE PIT
Sludge
DAVID BROMLEY ENGINEERING (1983) LTD
C.F.A. GAS PLANT
SLUDGE ASSESSMENT
TYPICAL GAS PLANT
2213-01
SAMPLE LOCATION
1
2
3

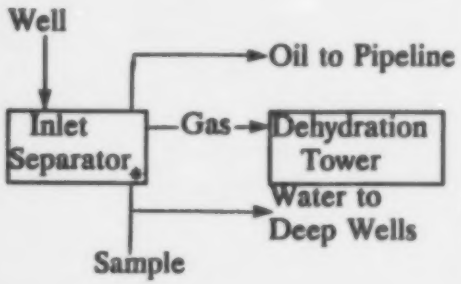
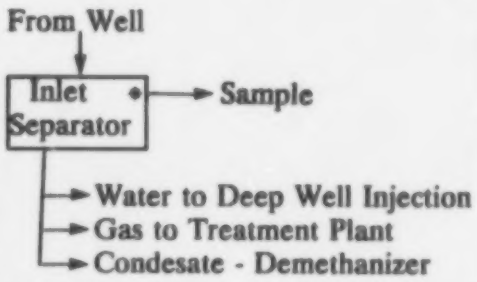
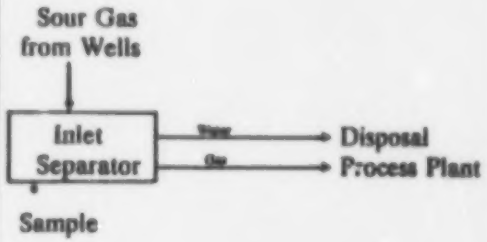
GLYCOL SYSTEM SLUDGE
Identification Number: 9

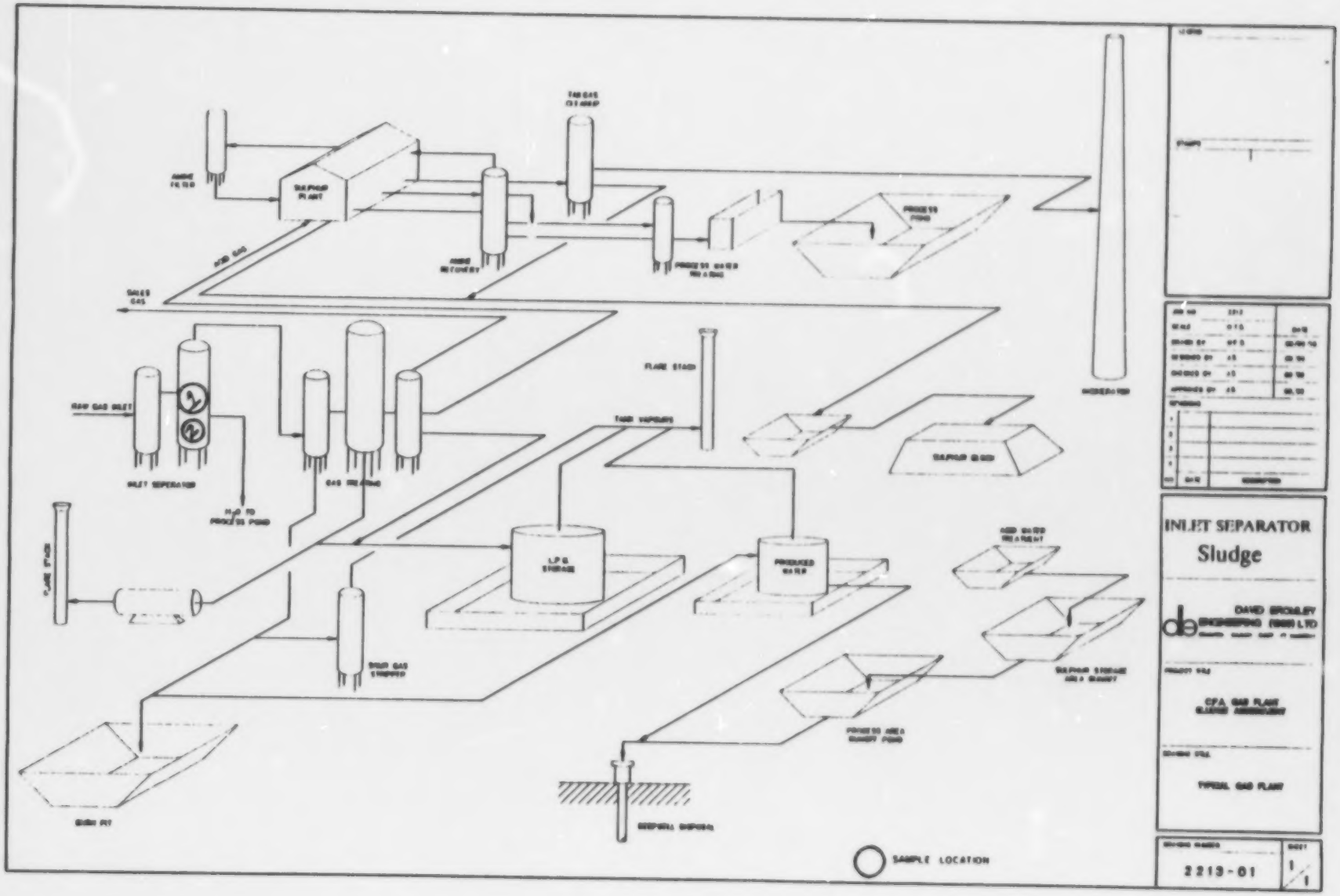
Sample #	1	2	3
Plant Specifics	Sour–Sulphur Recovery – 29 t/d using DEA Amine, no S–block is present. Constructed in 1961, capacity is 2,800,000 m3/d dry.	Sour–Sulphur Recovery – 29 t/d using DEA Amine, no S–block is present. Constructed in 1961, capacity is 2,800,000 m3/d dry.	Sweet, constructed in 1968, capacity is 240,000 m3/d dry.
Composite of	5 samples	4 samples	1 Sample
Date Sampled	4 December 1989	3 December 1989	Early January 1990
Analysis Began	9 February 1990	9 February 1990	6 February 1990
Analysis Complete	26 February 1990	26 February 1990	17 February 1990
Sample Location	Dehydrator units upstream of the gas plant (west).	Dehydrator unit upstream of the gas plant (east).	Sample obtained from the bottom of the dehydration tower.
Sampling Technique	Operator obtained the sample from the glycol filters.	Operator obtained the sample from the glycol filters.	At the base of the glycol dehydration tower is a 2 inch dump line to flush sediment out the bottom of the tower. The sample was taken from this line through a valve while the flush cycle was activated
Visual Description	Dark viscous sticky fluid.	Dark viscous sticky fluid.	Sandy–brown appearance.
Sample Source Diagram			


GLYCOL SYSTEM
Sludge
SAMPLE LOCATION
2219-01

INLET SEPARATOR SLUDGE
Identification Number: 10

CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

Sample # Plant Specifics	1 Sweet gas. Constructed in 1968, capacity is 240,000 m3/d dry.	2 Sour–Sulphur Recovery – 50 t/d using MEA Amine, no S–block is present. Constructed in 1960, capacity is 6,000,000 m3/d dry.	3 Sour – No Sulphur Recovery – MEA Amine Sweetening. Constructed in 1963, capacity is 3,350,000 m3/d dry.
Composite of	1 Sample		3 Samples
Date Sampled	Early January 1990	22 May 1990	14 June 1990
Analysis Began	6 February 1990		
Analysis Complete	17 February 1990	4 September 1990	4 September 1990
Sample Location	Sample obtained from the filter housing inside the inlet separator.	Inlet separator.	Inlet Separator
Sampling Technique	Sample was taken from under the filter housing and transferred to the sample bottle.	Plant was shut down. Sample was taken from the floor of the inlet separator vessel. A plastic bottle was used to scoop up sludge from several points and a composite was made.	Contents of the inlet separator were removed using a vacuum truck. Three grab samples were taken by the operator as the vacuum truck discharged its contents and were combined into a composite sample.
Visual Description	Blackish color.	Greyish liquid containing granular solids.	Black coloured with a fairly coarse consistency.
Sample Source Diagram			



INLET SEPARATOR
Sludge

DAVID BRICKLEY ENGINEERING (1988) LTD

CFA GAS PLANT

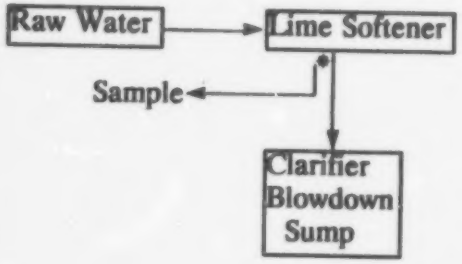
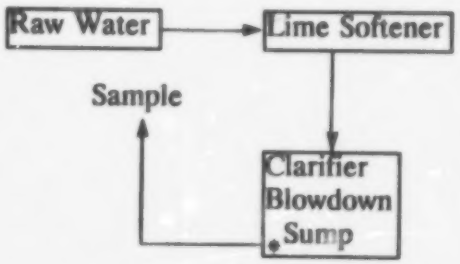
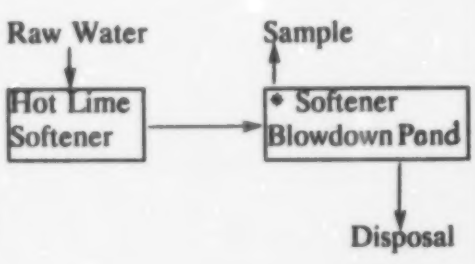
TYPICAL GAS PLANT

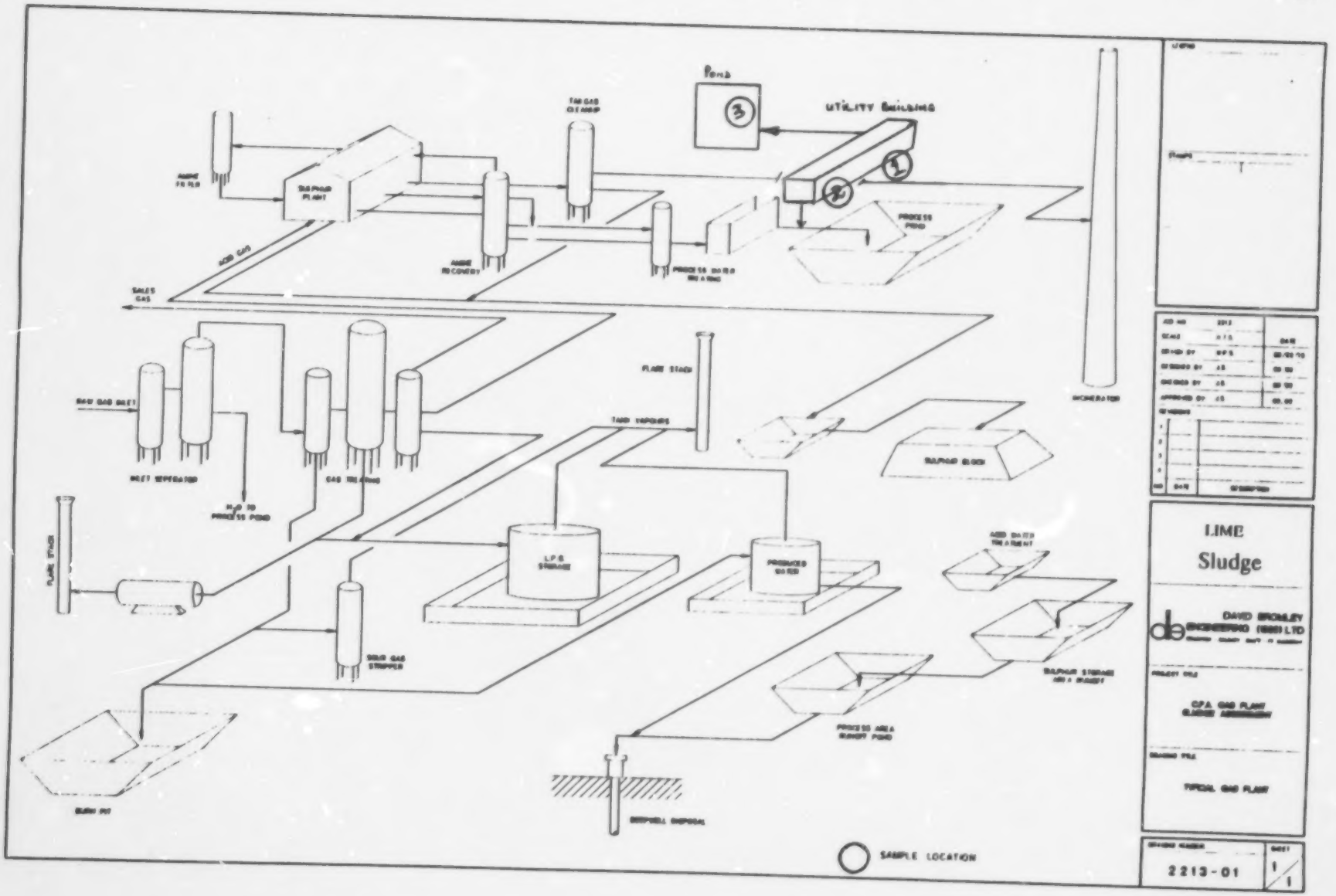
2219-01

1/1

LIME SLUDGE
Identification Number: 11

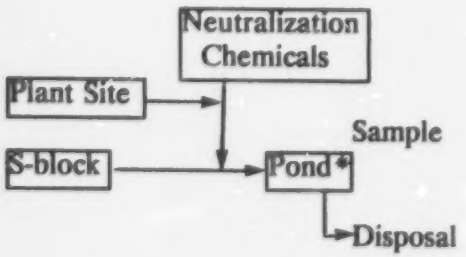
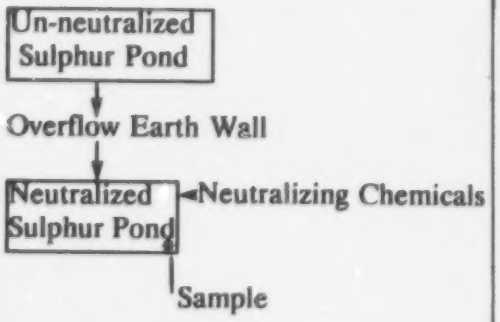
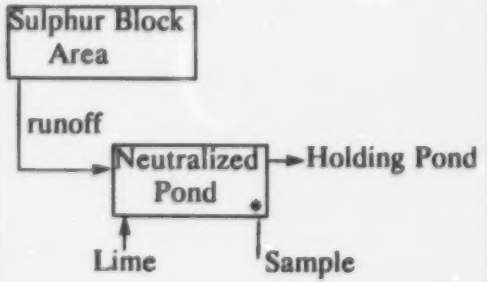
CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

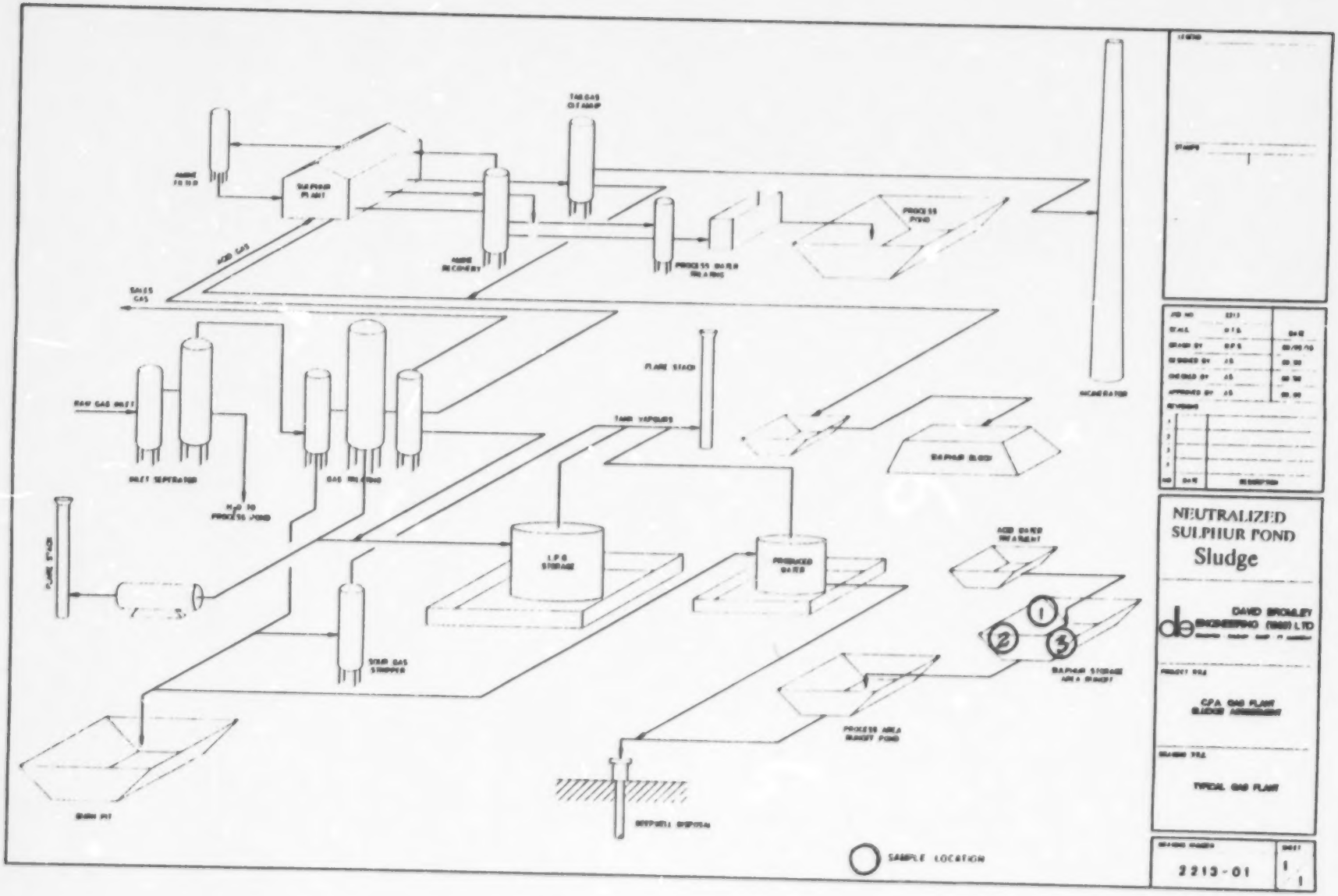
Sample # / Plant Specifics	1 Sour-Sulphur Recovery - 800 t/d using Sulfinol, S-block is present. Constructed in 1952, capacity is 6,000,000 m3/d dry.	2 Sour-Sulphur Recovery - 29 t/d using DEA Amine, no S-block is present. Constructed in 1960, capacity is 9,929,000 m3/d dry.	3
Composite of	1 Sample	5 Samples	2 Samples
Date Sampled	14 December 1989	10 January 1990	29 January 1990
Analysis Began	9 February 1990	6 February 1990	6 March 1990
Analysis Complete	26 February 1990	17 February 1990	28 March 1990
Sample Location	Sewer manhole outside of lime softener building.	Hot lime softener blowdown tank on the outside of the water treatment plant.	Lime storage pond.
Sampling Technique	Sample taken with a plastic beaker and transferred to a glass sample bottle.	Operator pumped sludge from the blow-down tank into a small flat tank. Several samples were taken out of the tank with a plastic beaker and a composite was transferred to the sample bottles.	Sludge taken from a pipe that transports hot lime softener to a lime storage pond. Two samples were taken with a clean pail about 1 m from shore and a composite wa made.
Visual Description	Thick, white slurry.	White liquid slurry.	Greyish slurry.
Sample Source Diagram			


Pond
3
UTILITY BUILDING
1
2
PROCESS POND
INCINERATOR
FLARE STACK
SULPHUR BLOCK
L.P.G. STORAGE
SAMPLE LOCATION
LIME
Sludge
DAVID BROMLEY ENGINEERING (1980) LTD
CPA GAS PLANT
TYPICAL GAS PLANT
2213-01
1/1

NEUTRALIZED SULPHUR POND SLUDGE
Identification Number: 12

CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

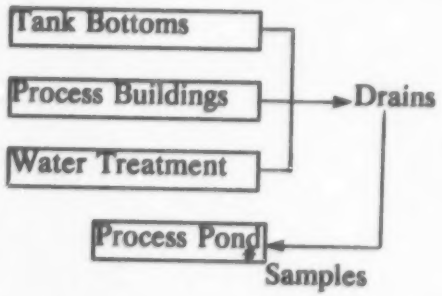
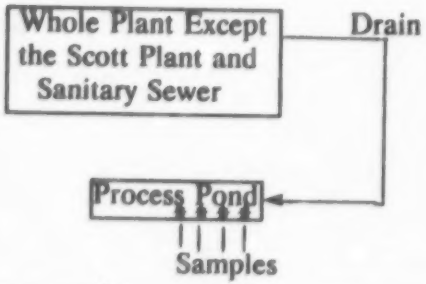
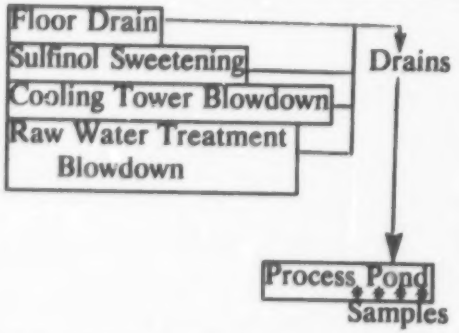
Sample # Plant Specifics	1 Sour-Sulphur Recovery - 800 t/d using Sulfinol, S-block is present. Constructed in 1952, capacity is 6,000,000 m3/d dry.	2 Sour-Sulphur Recovery - 2400 t/d using DIPA Amine and Sulfinol, S-block is present. Constructed in 1962, capacity is 8,875,000 m3/day dry.	3 Sour-Sulphur Recovery - 2400 t/d using DEA Amine, S-block is present. Constructed in 1971, capacity is 1,200,000 m3/d dry.
Composite of	1 Sample	1 Sample	3 Samples
Date Sampled	14 December 1989	6 December 1989	9 January 1990
Analysis Began	9 February 1990	9 February 1990	9 February 1990
Analysis Complete	26 February 1990	26 February 1990	26 February 1990
Sample Location	North side of an unlined earth basin.	Earth pond.	Large earthen pond. The pond was empty and sample was taken from bottom sedim
Sampling Technique	Ice was broken and a sample was taken with a plastic beaker.	Ice was broken and a metal scoop was used to obtain sample.	Sample composite taken from different spots near the inlet pipe.
Visual Description	White-brown slurry.	Brown on the surface, black below the surface.	Dried sludge was brownish-yellow.
Sample Source Diagram			


SALES GAS
FLARE STACK
INCINERATOR
LPG STORAGE
PRODUCED WATER
SAMPLE LOCATION
NEUTRALIZED SULPHUR POND
Sludge
DAVID BROMLEY ENGINEERING (1980) LTD
CFA GAS PLANT
TYPICAL GAS PLANT
2213-01

PROCESS POND SLUDGE
Identification Number: 13

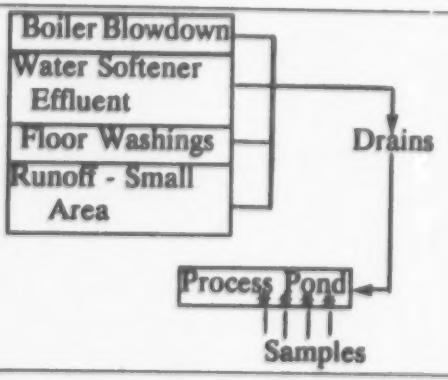
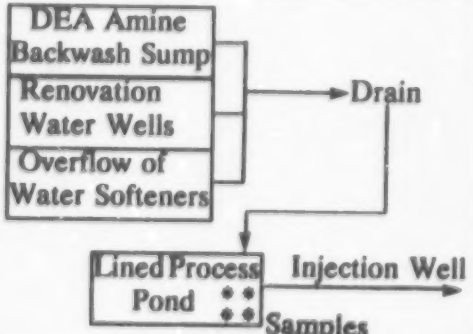
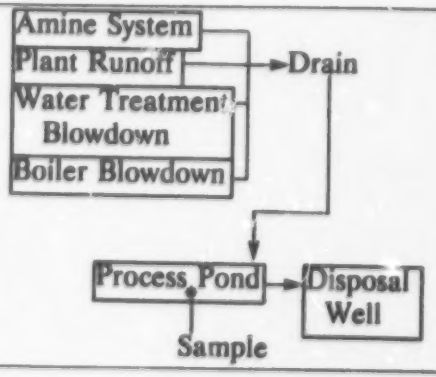
CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY

SAMPLING REPORT

Sample #	1	2	3
Plant Specifics	Sour-Sulphur Recovery - 28 t/d using DEA Amine, no S-block present. Constructed in 1961, capacity is 2,800,000 m3/d dry.	Sour-Sulphur Recovery - 2400 t/d using DIPA Amine and Sulfinol, S-block is present. Constructed in 1962, capacity is 8,875,000 m3/d dry.	Sour-Sulphur Recovery - 800 t/d using Sulfinol, S-block is present. Constructed in 1952, capacity is 6,000,000 m3/d dry.
Composite of	5 samples	4 samples	1 Sample
Date Sampled	7 November 1989	7 December 1989	14 December 1989
Analysis Began	9 February 1990		9 February 1990
Analysis Complete	26 February 1990		26 February 1990
Sample Location	Earthen pond.	Unlined earthen pond.	Earthen pond.
Sampling Technique	A composite was made from 5 samples taken from the bottom of the pond 3 m from shore. A vacuum sampling pump was used to collect the samples.	A composite was made from 4 samples taken from the bottom of the pond near shore.	The sample was taken with a plastic beaker attached to an extension pole.
Visual Description	Very black and oily.	Black and oily.	Very black and sticky. No free oil was observed. Pond contains H2S process water.
Sample Source Diagram			

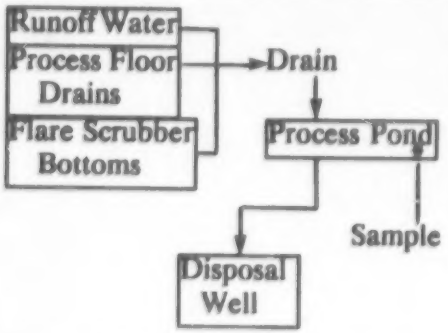
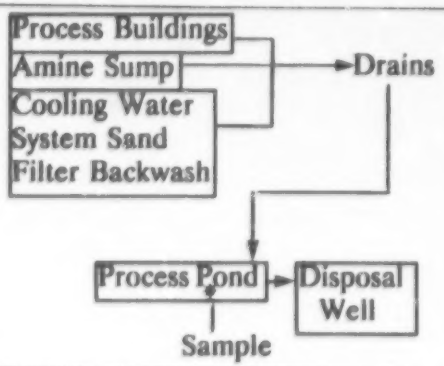
PROCESS POND SLUDGE
Identification Number: 13

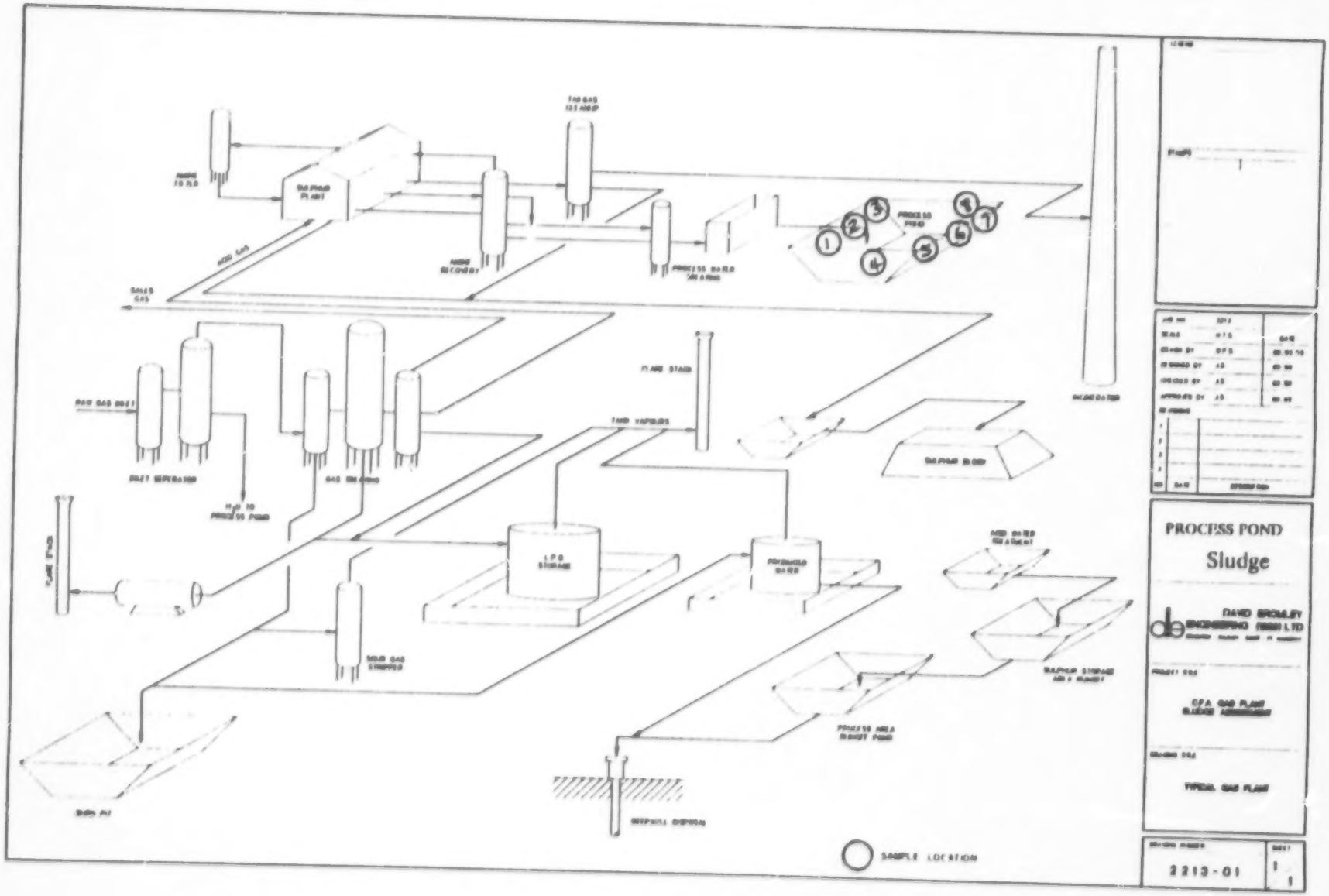
CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

Sample # / Plant Specifics	4 Sour-Sulphur Recovery – 200 t/d using DEA Amine, S-block is present. Constructed in 1965, capacity is 2,617,000 m3/d dry.	5 Sour-Sulphur Recovery – 943 t/d using DEA Amine, S-block is present. Constructed in 1962, capacity is 6,443,000 m3/d dry.	6 Sour-Sulphur Recovery – 100 t/d using MEA Amine, no S-block is present. Constructed in 1956, capacity is 1,839,000 m3/d dry.
Composite of	4 samples	4 samples	
Date Sampled	14 December 1989	9 January 1990	16 March 1990
Analysis Began	9 February 1990	6 February 1990	6 April 1990
Analysis Complete	26 February 1990	17 February 1990	23 April 1990
Sample Location	Earthen pond.	Lined pond.	Lined pond.
Sampling Technique	A long handled shovel was used to obtain the samples from the bottom of the pond 3m from shore.	The samples were taken from the lined pond after the liquid had been pumped out. A plastic beaker was used to collect and mix the samples.	Sample was taken from one spot using a vacuum sampling apparatus. It was not possible to get a composite sample due to ice on the pond.
Visual Description	Very black, oily and viscous, with a strong offensive odor.	Black thick sludge with a strong odor.	Dark color, fairly granular. No odors.
Sample Source Diagram			

PROCESS POND SLUDGE
Identification Number: 13

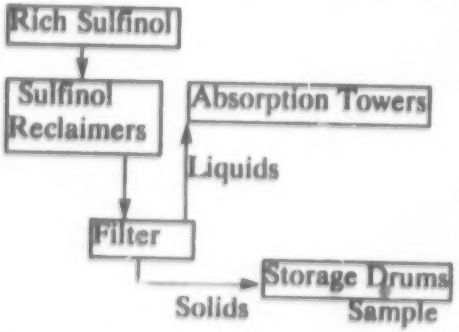
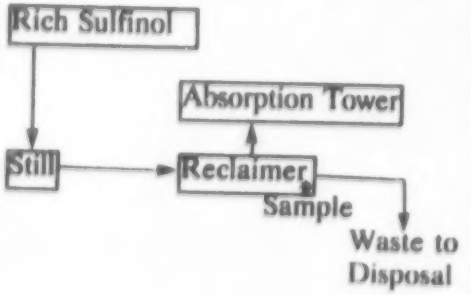
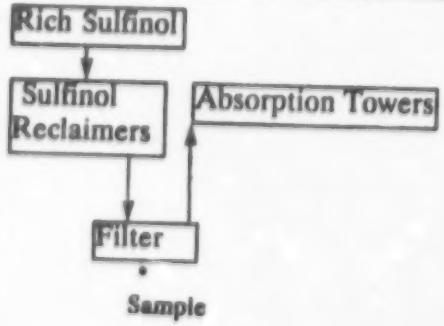
CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

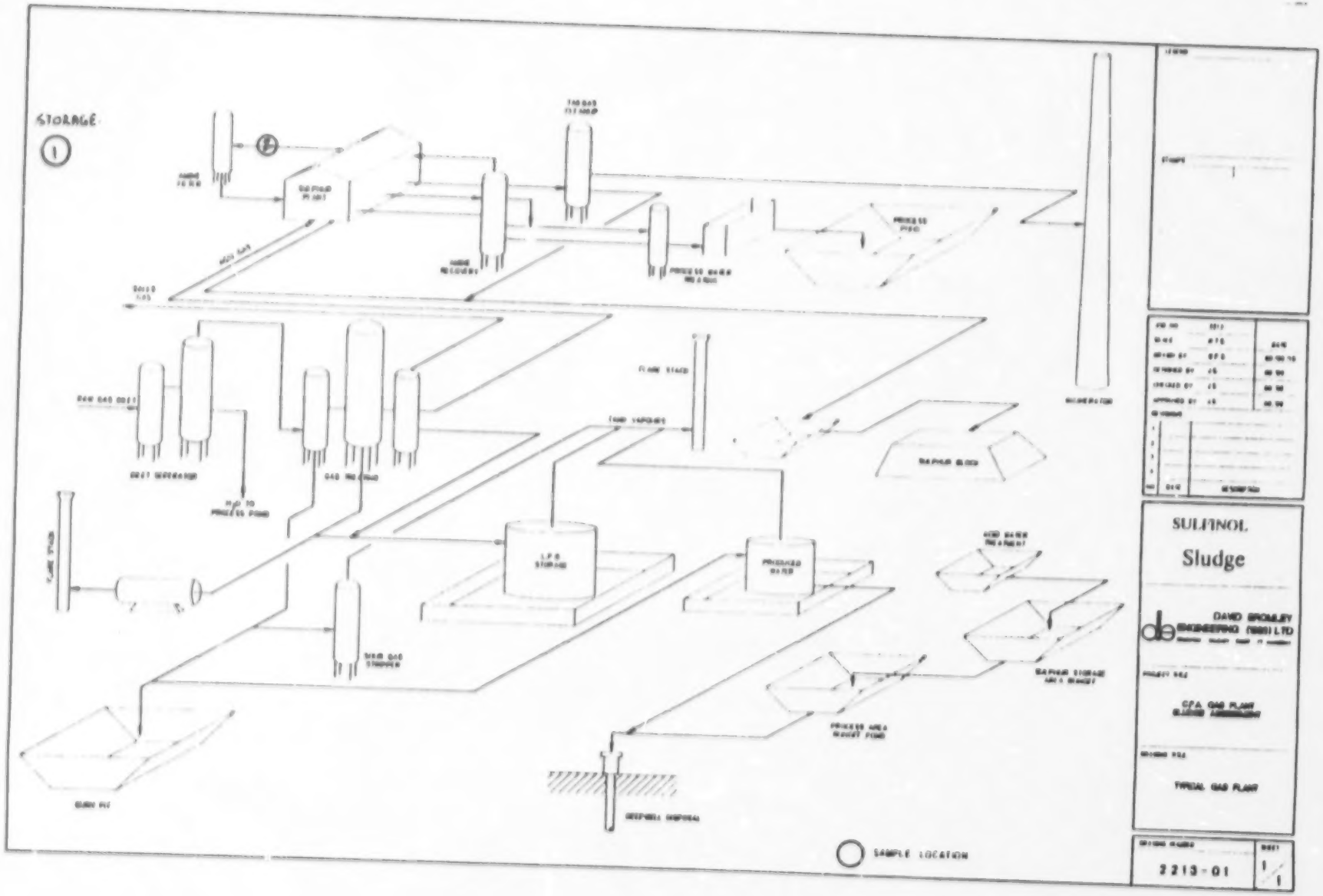
Sample #	7	8	9
Plant Specifics	Sour-Sulphur Recovery -- 12 t/d using DEA Amine, no S-block present. Constructed in 1954, capacity is 1,836,000 m3/d dry.	Constructed in 1964. Straddle plant.	
Composite of	3 samples	1 Sample	
Date Sampled	5 March 1990	2 March 1990	
Analysis Began	6 April 1990	6 April 1990	
Analysis Complete	23 April 1990	23 April 1990	
Sample Location	South end of process pond.	Taken from east side of a rubber lined process pond.	
Sampling Technique	A composite of three samples were taken using the vacuum sampling apparatus.	Sample taken using vacuum sampling apparatus.	
Visual Description	Greyish-black with a fine texture.	Black with a coarse sandy texture and fairly oily.	
Sample Source Diagram			


PROCESS POND
Sludge
DAVID BROMLEY ENGINEERING (1990) LTD
CFA GAS PLANT
TYPICAL GAS PLANT
2213-01
SAMPLE LOCATION

SULFINOL SLUDGE
Identification Number: 14

CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

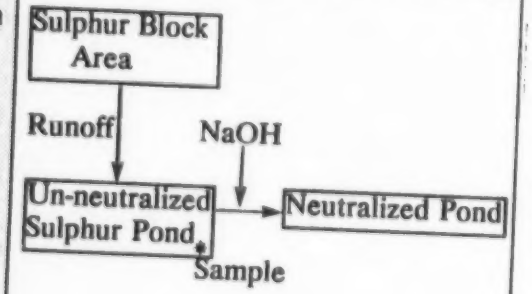
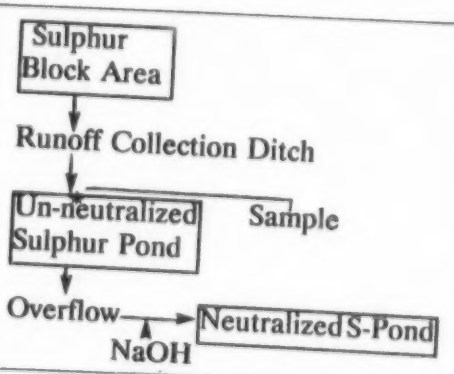
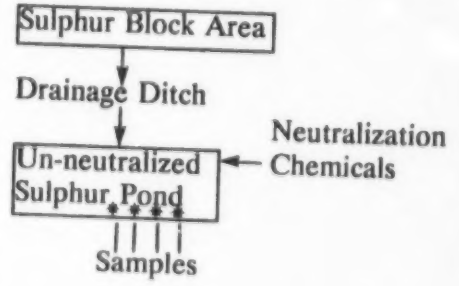
Sample # / Plant Specifics	1 Sour-Gas Flare – 5 t/d using DEA Amine and Sulfinol, no S-block is present. Constructed in 1967, capacity is 1,226,000 m3/d dry.	2 Sour-Sulphur Recovery – 800 t/d using Sulfinol, S-block is present. Constructed in 1967, capacity is 6,000,000 m3/d dry.	3 Sour-Sulphur Recovery – 800 t/d using Sulfinol, S-block is present. Constructed in 1952, capacity is 6,000,000 m3/d dry.
Composite of	1 Sample	1 Sample	1 Sample
Date Sampled	7 December 1989	17 May 1990	14 December 1989
Analysis Began	9 February 1990		9 February 1990
Analysis Complete	26 February 1990		26 February 1990
Sample Location	Sample taken from drum containing sludge from reclaimer vessel which was cleaned out during 1989 turnaround.	Amine reclaimer.	Reclaimer filters.
Sampling Technique	A metal pipe was used to dig sludge out of the drum. Sludge was then placed in a glass sample bottle.	The sample was taken from a dump valve which is used to remove degradation products from circulating amine solution.	The sample was taken by squeezing sludge from a filter.
Visual Description	Dark brown to black. Very viscous.	Thick blackish fluid.	Dark brown to black. Very viscous.
Sample Source Diagram			

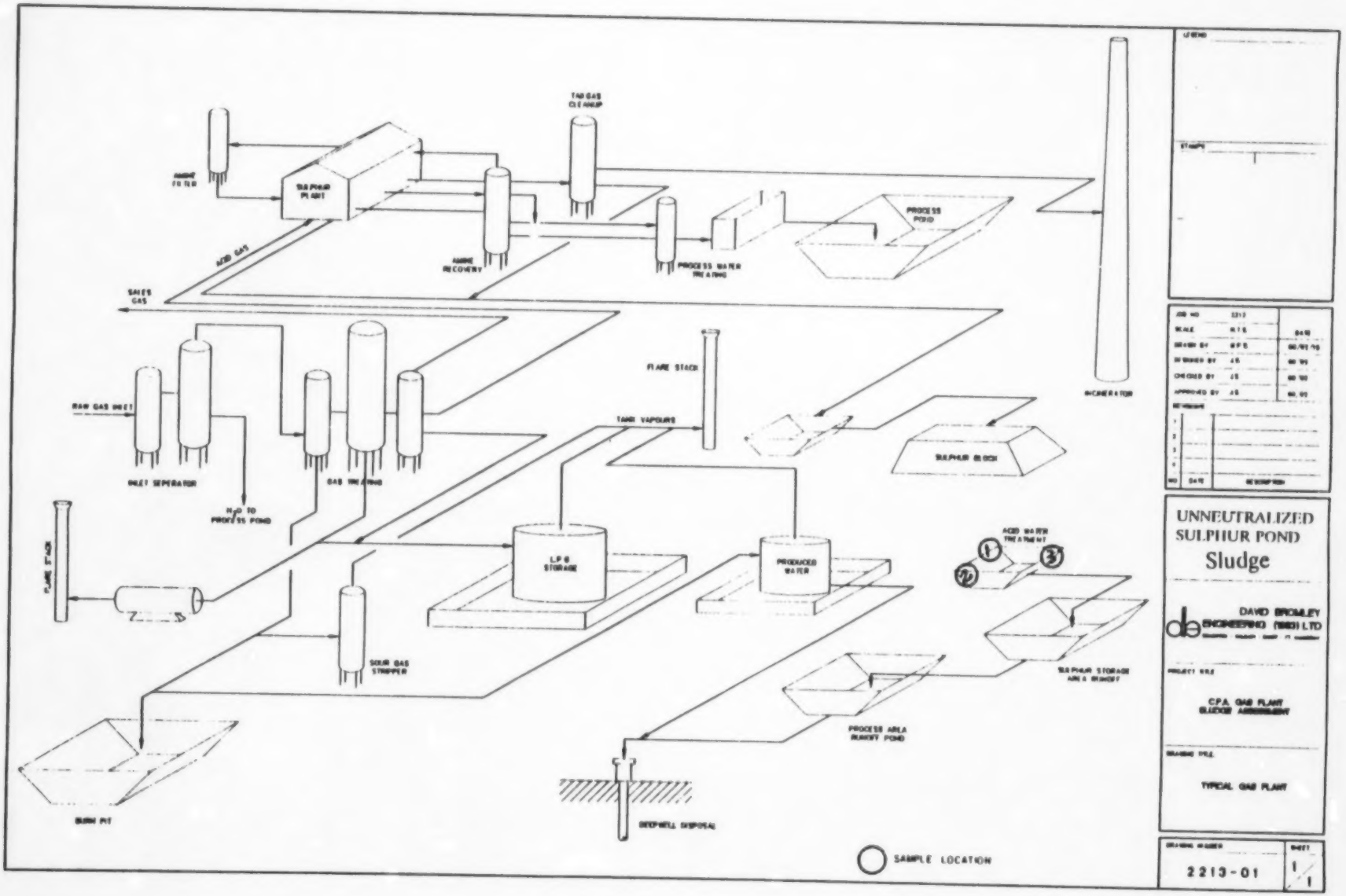

STORAGE
1
SAMPLE LOCATION
SULFINOL
Sludge
DAVID BROMLEY ENGINEERING (1981) LTD
CFA GAS PLANT
TYPICAL GAS PLANT
2213-01

UNNEUTRALIZED SULPHUR POND SLUDGE
Identification Number: 15

CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY

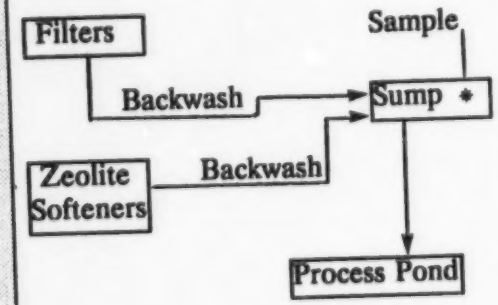
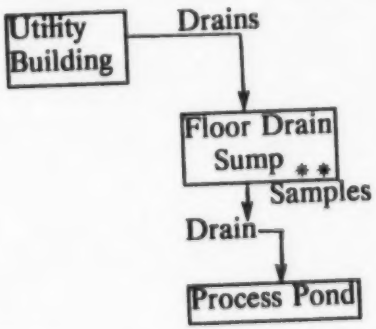
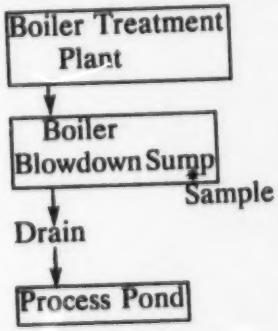
SAMPLING REPORT

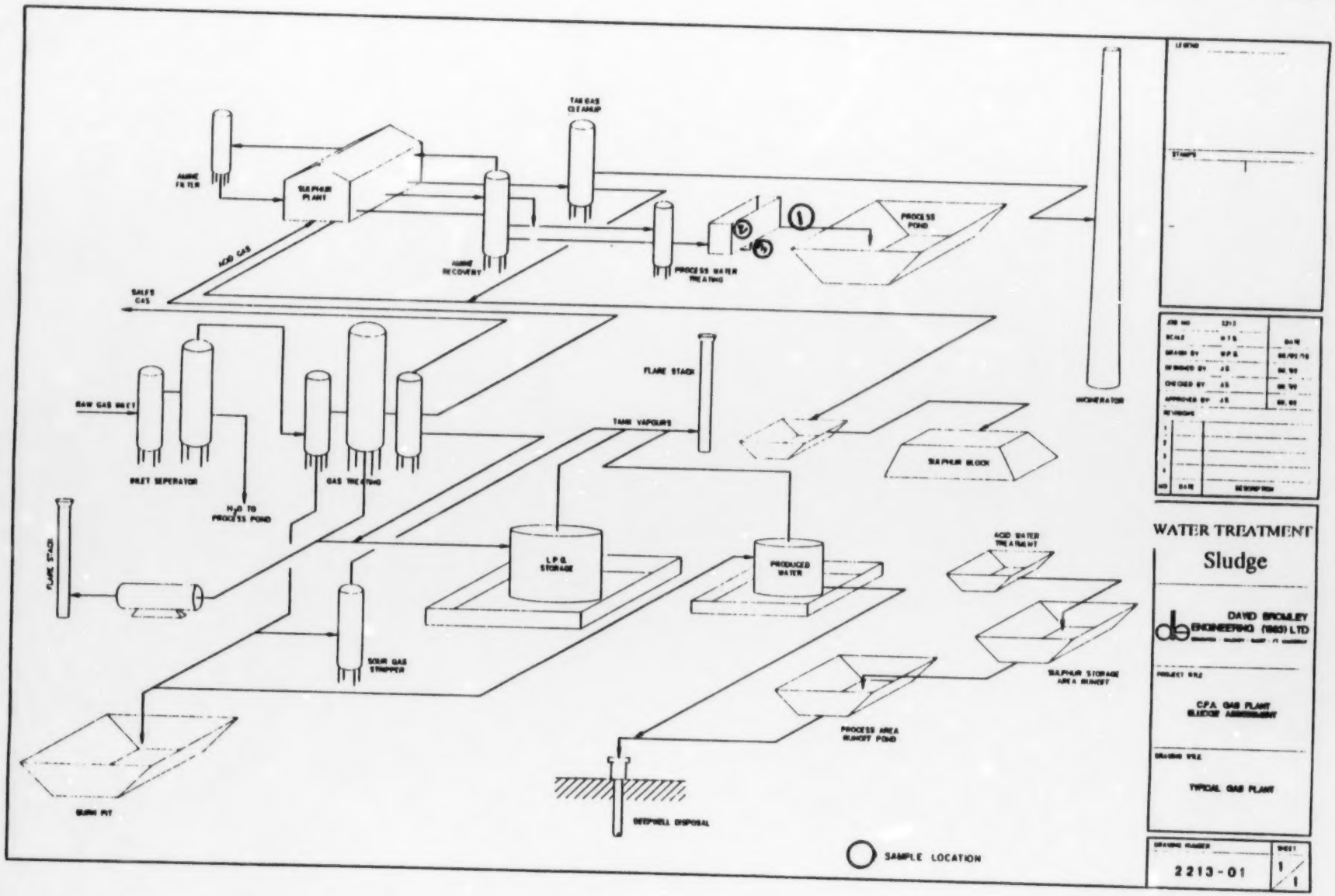
Sample # / Plant Specifics	1 Sour-Sulphur Recovery – 2400 t/d using DIPA Amine and Sulfinol, S-block is present. Constructed in 1962, capacity is 8,875,000 m3/d dry.	2 Sour-Sulphur Recovery – 943 t/d using DEA Amine, S-block is present. Constructed in 1971, capacity is 6,443,000 m3/d dry.	3 Sour-Sulphur Recovery – 23 t/d using DEA Amine, S-block is present. Constructed in 1972, capacity is 90,000 m3/d dry.
Composite of	1 Sample	4 Samples	4 Samples
Date Sampled	6 December 1989	9 January 1990	8 January 1990
Analysis Began	9 February 1990	6 February 1990	6 February 1990
Analysis Complete	26 February 1990	17 February 1990	17 February 1990
Sample Location	Earth pond, frozen.	Earthen reservoir into which runoff from the sulphur block flows.	Earthen pond on the western side of the sulphur block.
Sampling Technique	Ice was broken and a 500 ml sample was taken and placed in the glass sample bottle.	Sample taken at the inlet to the pond. Four samples were taken and a composite was transferred to the glass sample bottle.	Four samples were taken using a plastic scoop on a 2 m long pole.
Visual Description	Sludge was brownish in color, and contained significant amounts of elemental sulphur.	Fine textured a with grey-brown color.	Fine textured material with a brownish col
Sample Source Diagram			


SULPHUR PLANT
AMINE REGEN
TAIL GAS CLEANUP
AMINE RECOVERY
PROCESS WATER TREATING
PROCESS POND
ACID GAS
SALES GAS
INCINERATOR
FLARE STACK
TANK VAPOURS
RAW GAS INLET
INLET SEPARATOR
GAS TREATING
H2O TO PROCESS POND
SULPHUR BLOCK
FLARE STACK
L.P.G. STORAGE
PRODUCED WATER
ACID WATER TREATMENT
SOUR GAS STRIPPER
SULPHUR STORAGE AREA RUNOFF
PROCESS AREA RUNOFF POND
BURN PIT
DEEPWELL DISPOSAL
SAMPLE LOCATION
UNNEUTRALIZED SULPHUR POND
Sludge
DAVID BROMLEY ENGINEERING (1983) LTD
CPA GAS PLANT
TYPICAL GAS PLANT
2213-01

WATER TREATMENT SLUDGE
Identification Number: 16

CPA GAS PLANT SLUDGE TREATMENT TECHNOLOGY STUDY
SAMPLING REPORT

Sample # / Plant Specifics	1 Sour–Sulphur Recovery – 800 t/d using Sulfinol, S–block is present. Constructed in 1952, capacity is 6,000,000 m3/d dry.	2 Sour–Sulphur Recovery – 850 t/d using DEA Amine, S–block is present. Constructed in 1983, capacity is 6,880,000 m3/d dry.	3 Sour–Sulphur Recovery – 12 t/d using DEA Amine, no S–block is present. Constructed in 1954, capacity is 1,836,000 m3/d dry.
Composite of	1 Sample	1 Sample	2 samples
Date Sampled	14 December 1989	11 January 1990	15 January 1990
Analysis Began	9 February 1990	6 February 1990	6 February 1990
Analysis Complete	26 February 1990	17 February 1990	17 February 1990
Sample Location	Open culvert used for zeolite softener blowdown.	Sump inside the utility building.	Seven m deep concrete sump outside of the boiler and water treatment plant.
Sampling Technique	Sample taken with plastic beaker from sides of culvert. Transferred to glass sample bottle.	Sample taken from the bottom of the sump using vacuum sampling apparatus. Sample sucked into a glass flask and transferred to a glass sample bottle.	Two samples were taken using the vacuu sampling apparatus.
Visual Description	Reddish–brown, crystalline, semi–solid.	Black and fairly oily.	Black and fairly coarse in texture.
Sample Source Diagram			


AMINE FILTER
SULPHUR PLANT
TAIL GAS CLEANUP
ACID GAS
AMINE RECOVERY
PROCESS WATER TREATING
PROCESS POND
SALES GAS
INCINERATOR
FLARE STACK
RAW GAS INLET
TANK VAPOURS
SULPHUR BLOCK
INLET SEPERATOR
H2O TO PROCESS POND
GAS TREATING
FLARE STACK
L.P.G. STORAGE
PRODUCED WATER
ACID WATER TREATMENT
SOUR GAS STRIPPER
SULPHUR STORAGE AREA RUNOFF
PROCESS AREA RUNOFF POND
BURN PIT
DEEPWELL DISPOSAL
SAMPLE LOCATION
WATER TREATMENT
Sludge
DAVID BROMLEY ENGINEERING (1983) LTD
CFA GAS PLANT
BLEDOW ASSESSMENT
TYPICAL GAS PLANT
2213-01
1/1

APPENDIX E

QUALITY CONTROL REPORTS

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Total Organic Carbon in soil

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 9/90	0.88%	0.84%	105.
	0.82	0.84	98.
Feb. 14/90	0.89	0.87	102.

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Total Phosphorus by ICP

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 1990	507 ug/g	540 ug/g	93.8
Feb. 15/90	460	540	85.2

Check Sample was National Bureau of Standards Standard Reference Material 1646

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Total Sulphur (Leco) Units - wt.%

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 25/90	2608-3	<0.1	<0.1	0.		
	2608-14	1.18	1.34	0.16		
	2608-17	2.12	2.03	0.09		
	2246-1	0.38	0.36	0.02		
Apr. 10/90	317-4	.54	.64	0.10		

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Total Kjeldahl Nitrogen

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 23/90	0.56	0.57	98.2
Feb.15/90	0.55	0.57	110.
Apr. 11/90	0.60	0.57	105.3

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Jan. 23/90	2608-18	1.26	1.17	108.
Feb. 15/90	2911-8	0.53	0.53	100.
Apr. 11/90	302-3D	0.98	1.00	98.0

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 23/90	2608-14	0.16	0.15	0.01	0.03	yes
	2608-18	0.15	0.13	0.02	0.03	yes
Feb. 15/90	2911-7	0.70	0.66	0.04	0.07	yes
Apr. 11/90	330-1	11.0	12.0	1.0	2.0	yes

QUALITY CONTROL RESULTS
David Bromley Enguneering Ltd.

Sample #2608, 2246, 317

Parameter: pH

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 15/90	2608-10	7.40	7.41	0.01	0.1	yes
	2608-17	7.34	7.36	0.01	0.1	yes
APr. 10/90	317-10	8.38	8.29	0.09	0.1	

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608-2246, 2874, 317

Parameter: Conductivity (umhos)

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 15/90	2608-10	2430	2490	60.	150.	yes
Feb. 5/90	2874-5	5340	5440	100.	150.	yes
Apr. 11/90	317-10	1560	1440	120.	150.	yes

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Calcium (ppm)

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 17/90	40.	40.	100.
Feb. 5/90	42.	40.	105.
Apr. 12/90	36.	40.	90.

Duplicates

Date	Sample #	Orig.Value	Dupl.Vaiue	Difference	Allow.Diff.	Acceptable
Jan. 17/90	2608-10	340.	300.	40.		
	2608-17	720.	720.	0.		
Feb. 5/90	2874-5	160.	240.	80.		
Apr. 12/90	317-10	20.	40.	20.		

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Magnesium (ppm)

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 17/90	22.	20.	110.
Feb. 5/90	19.5	20.	97.
Apr. 12/90	19.5	20.	97.5

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 17/90	2608-10	122.	110.	12.		
	2608-17	73.2	73.2	0.		
Feb. 5/90	2874-5	49.	49.	0.		
Apr. 12/90	317-10	10.9	12.2	1.3		

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Sodium (ppm)

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 16/90	687.	641.	107.
Feb. 2/90	678.	641.	106.
Apr. 12/90	692.	641.	108.

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 16/90	2608-10	742.	742.	0.		
	2608-17	1928.	1840.	88.		
Feb.2/90	2874-5	160.	160.	0.		
Apr. 12/90	317-10	183.	220.	37.		

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Potassium (ppm)

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 16/90	40.2	39.1	103.
Feb. 2/90	39.9	39.1	102.
Apr. 12/90	43.4	39.1	111.

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 16/90	2608-10	45.4	46.9	1.5		
	2608-17	205.	198.	7.		
Feb. 2/90	2874-5	10.9	10.9	0.		
Apr. 12/90	317-10	10.9	12.2	1.3		

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Chloride by Ion Chromatography

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Feb. 7/90	7.6	8.0	95.0
Feb. 6/90	7.7	8.0	96.2
Apr. 16/90	7.9	8.0	98.7

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Feb. 7/90	1874-9	7.7	7.7	100.
Feb. 6/90	2417-20	6.9	6.8	101.
Apr. 16/90	372-4	8.29	8.23	100.7

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Feb. 7/90	2874-9	5.4	5.4	0.	0.9	yes
Feb. 6/90	2417-20	3.5	3.6	0.1	0.6	yes
Apr. 16/90	372-3	29.0	28.8	0.2	1.3	yes
	317-10	33.8	33.3	0.5	1.3	yes

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Sulphate by Ion Chromatography

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Feb. 7/90	5.9	6.0	98.3
Feb. 6/90	6.2	6.0	103.
Apr. 16/90	5.9	6.0	98.3

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Feb. 7/90	2874-9	28.0	27.8	100.7
Feb. 6/90	2417-20	29.3	29.3	100.
Apr. 16/90	372-4	33.3	33.3	100.0

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Feb. 7/90	2874-9	30.0	30.5	0.5	2.5	yes
Feb. 6/90	2417-20	33.6	34.2	0.6	2.5	yes
Apr. 16/90	317-10	65.4	61.4	4.	4.8	yes

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Bicarbonate

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 18/90	2608-10	455.	412.	43.		
Feb. 5/90	2874-5	3080.	2920.	160.		
Apr.11/90	317-10	335.	345.	10.		

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Nitrate

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Feb.7/90	0.071	0.068	104.

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Feb. 7/90	2874-6	0.58	0.56	96.5

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Feb. 7/90	2874-6	0.210	0.198	0.012		

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Sulphide (Iodometric Method)

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Feb. 14/90	92.	92.	100.
Apr. 10/90	69.1	73.3	94.2

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Feb. 14/90	3002-2	1760.	1760.	0.		
Apr.10/90	317-9	307.8	307.8	0.		

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 317

Parameter: Cyanide

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 24/90	0.046	0.043	107.
	0.044	0.043	102.3
Feb. 6/90	0.042	0.043	97.6
	0.043	0.043	100.
Apr.11/90	0.050	0.051	98.0
	0.051	0.051	100.0

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Jan. 24/90	2823-11	0.024	0.024	100.
	2608-5	0.026	0.026	100.
Feb. 6/90	2941-2	0.024	0.025	96.0
	2907-T3	0.040	0.046	87.0
Apr. 11/90	318-33	0.027	0.028	96.4
	319-1	0.054	0.054	100.0

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 24/90	2608-10	0.002	0.002	0.	0.003	yes
	2608-17	0.085	0.087	0.002	0.005	yes
	2608-12	0.001	0.001	0.	0.003	yes
Feb. 6/90	2874-2	0.06	0.06	0.	0.005	yes
	2874-10	0.06	0.06	0.	0.005	yes
	2874-5	0.22	0.24	0.02	0.01	yes
Apr. 11/90	317-4	0.001	<0.001	0.001	0.003	yes

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Arsenic

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 25/90	0.0018	0.0018	100.
Feb. 13/90	0.0009	0.0008	112.5
	0.0010	0.0008	125.0
Apr. 18/90	0.0009	0.0008	112.5

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Jan. 25/90	2709-215A	0.005	0.005	100.
	2784-1	0.008	0.0077	103.9
Feb. 13/90	2960-1	0.0063	0.0063	100.
	2947-1	0.0065	0.0069	94.2
Apr. 18/90	372-2	0.0056	0.0057	98.2
	386-1	0.0073	0.0072	101.3

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 25/90	2246-2	0.0033	0.0035	0.0002	0.0006	yes
	2608-4	0.0027	0.0029	0.0002	0.0003	yes
	2735-1	0.0050	0.0051	0.0001	0.0006	yes
	2774-2	0.0010	0.0009	0.0001	0.0003	yes
Feb. 13/90	2874-1	0.0011	0.0013	0.0002	0.0003	yes
	2874-13	0.0029	0.0029	0.	0.0003	yes
Apr. 18/90	135-1	0.0006	0.0005	0.0001	0.0003	yes
	317-10	0.0012	0.0014	0.0002	0.0003	yes

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Selenium

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 25/90	0.0017	0.0015	113.
	0.0007	0.0009	77.7
Feb. 13/90	0.0010	0.0009	111.
Apr. 18/90	0.0009	0.0008	112.5

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Jan. 25/90	2709-215A	0.0053	0.0052	102.
	2784-1	0.0055	0.0056	97.7
Feb. 13/90	2960-1	0.0068	0.0065	105.
	2947	0.0045	0.0050	90.0
Apr. 18/90	372-2	0.0052	0.0053	98.1
	386-1	0.0052	0.0050	104.

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 25/90	2246-2	<0.0002	<0.0002	0.	0.0003	yes
	2608-4	<0.0002	<0.0002	0.	0.0003	yes
	2735-1	0.0018	0.0020	0.0002	0.0003	yes
	2774-2	0.0005	0.0005	0.	0.0003	yes
Feb. 13/90	2874-1	<0.0002	<0.0002	0.	0.0003	yes
	2874-13	<0.0002	<0.0002	0.	0.0003	yes
Apr. 18/90	317-10	<0.0002	<0.0002	0.	0.0003	yes
	376-3	<0.0002	<0.0002	0.	0.0003	yes

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Mercury (ppb)

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 24/90	10.9	10.	109.
Feb. 8/90	9.7	10.	97.0
Apr. 18/90	1.10	10.	110.0

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Jan. 24/90	1841-10	0.46	0.525	87.6
	2807-1	0.60	0.57	105.
Feb. 8/90	2966-1	0.71	0.70	101.
Apr. 18/90	372-2	1.08	1.10	98.2

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 24/90	2841-10	0.05	0.05	0.	0.005	yes
	2662-1	0.05	0.05	0.	0.005	yes
	2868-1	0.05	0.05	0.	0.005	yes
Feb. 8/90	2900-1	0.41	0.44	0.03	0.05	yes
Apr. 18/90	372-2	0.18	0.21	0.03	0.24	yes

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Barium by ICP

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 25/90	0.201	0.207	97.1
Feb. 7/90	0.200	0.207	96.6
Apr. 23/90	0.431	0.460	93.6

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Jan. 25/90	2608-17	0.753	0.753	100.
Feb. 7/90	2874-12	0.191	0.193	98.9
Apr. 23/90	317-6	0.243	0.256	94.9

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 25/90	2608-17	1.32	1.30	0.02	0.05	yes
	2608-2	232.	238.	6.	10.	yes
Feb. 7/90	2874-12	0.18	0.179	0.001	0.005	yes

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Boron by ICP

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 25/90	0.147	0.153	96.1
Feb. 7/90	0.148	0.153	96.7
Apr. 23/90	0.300	0.34	88.2

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Jan. 25/90	2608-17	0.327	0.316	103.5
Feb. 7/90	2874-12	0.082	0.082	100.
Apr. 23/90	317-6	0.266	0.225	118.2

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 25/90	2608-17	0.51	0.48	0.03	0.05	yes
Feb. 7/90	2874-12	0.019	0.011	0.008	0.009	yes
	2895-1	0.062	0.054	0.008	0.009	yes

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Cadmium by ICP

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 25/90	0.144	0.144	100.
Feb. 7/90	0.143	0.144	99.3
Apr. 23/90	0.314	0.32	98.1

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Jan. 25/90	2608-17	0.07	0.072	97.2
Feb. 7/90	2874-12	0.098	0.085	115.
Apr. 23/90	317-6	0.157	0.163	96.3

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 25/90	2608-3	<0.001	<0.001	0.	0.003	yes
	2608-17	<0.001	<0.001	0.	0.003	yes
Feb. 7/90	2874-12	0.024	0.025	0.001	0.003	yes
	2895-1	<0.001	<0.001	0.	0.003	yes

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Lead by ICP

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 25/90	0.166	0.162	102.5
Feb. 7/90	0.169	0.162	104.3
Apr. 23/90	0.350	0.36	97.2

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Jan. 25/90	2608-17	0.076	0.083	91.6
Feb. 7/90	2874-12	0.099	0.088	112.5
Apr. 23/90	317-6	0.223	0.222	100.5

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 25/90	2608-3	0.01	0.02	0.01	0.02	yes
	2608-17	<0.01	<0.01	0.	0.02	yes
Feb. 7/90	2874-12	<0.010	0.015	0.005	0.02	yes
	2895-1	0.021	0.019	0.002	0.02	yes

QUALITY CONTROL RESULTS
David Bromley Engineering Ltd.

Sample #2608, 2246, 2874, 317

Parameter: Chromium by ICP

Standard Check Solution (prepared by QA/QC)

Date	Value	Theoretical Value	% Recovery
Jan. 25/90	0.167	0.171	97.7
Feb. 7/90	0.163	0.171	95.3
Apr. 23/90	0.351	0.380	92.3

Analyst-Prepared Spikes

Date	Sample	Value	Theoretical Value	% Recovery
Jan. 25/90	2608-17	0.160	0.164	97.7
Feb. 7/90	2874-12	0.080	0.088	90.9
Apr. 23/90	317-6	0.209	0.204	102.5

Duplicates

Date	Sample #	Orig.Value	Dupl.Value	Difference	Allow.Diff.	Acceptable
Jan. 25/90	2608-17	0.164	0.157	0.007	0.01	yes
Feb. 7/90	2874-12	0.003	0.005	0.002	0.002	yes
	2895-1	0.003	0.003	0.	0.002	yes